Title: The upland mixed fir coniferous forest "Abietetum albae" Dziubałtowski 1928 in the central part of the Cracow-Częstochowa Upland : differentiation, regional specificity, structure, dynamics, and maintenance

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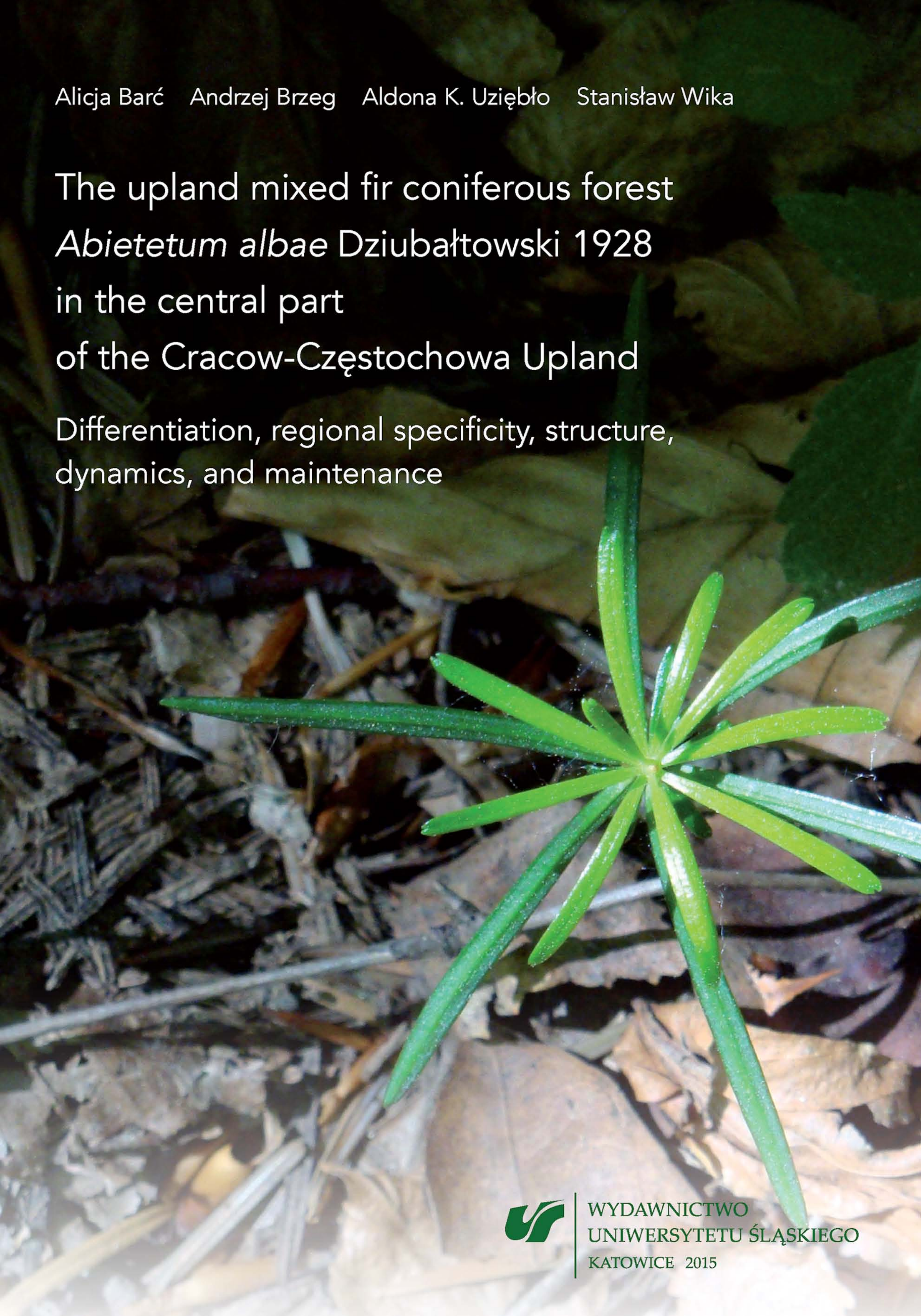

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Differentiation, regional specificity, structure, dynamics, and maintenance

WYDAWNICTWO
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dr Alicja Barć – adiunkt w Katedrze Geobotaniki i Ochrony Przyrody, a od 2014 roku w Katedrze Ekologii na Wydziale Biologii i Ochrony Środowiska, Uniwersytetu Śląskiego w Katowicach. Autorka monografii „Jodła pospolita *Abies alba* Mill. w lasach Beskidu Małego" (2012) oraz innych prac z dziedziny geobotaniki, ekologii i ochrony przyrody, dotyczących w szczególności roślinności oraz wybranych gatunków Karpat Zachodnich, Wyżyny Krakowsko-Częstochowskiej i Wyżyny Śląskiej. Członkini Oddziału Śląskiego Polskiego Towarzystwa Botanicznego oraz Komisji Ochrony Środowiska i Gospodarki Odpadami PAN, Oddział w Katowicach, audytor wewnętrzny systemów zarządzania jakością ISO 9001 i ISO 14001, wieloletni współpracownik Muzeum Górnictwa Węglowego w Zabrzu.

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Introduction

The silver fir *Abies alba* Mill. is a mountain species native to central and south European type of range that reaches the lowlands at the northern part of its distribution (Białobok 1983; Danielewicz 2012). Its latitudinal range includes the most northern sites in the Białowieża Primaeval Forest, that is, the Tisovik reserve in Belarus (Szafer 1920; Korczyk et al. 1997), as well as the Aspromonte Mts. (Calabria, Italy), the Pyrenees, and other southern localities, for example, the Stara Planina in Bulgaria. Its altitudinal range increases from north to south — from 150 m a.s.l. in the Tisovik reserve up to for example 800—1800 (2100) m a.s.l. in the Apennines, 600—1900 m a.s.l. in the Italian Alps, 900—1800 (2100) m a.s.l. in the Pyrenees, and (400) 1000—2000 m a.s.l. in the Stara Planina (Białobok 1983).

The silver fir is a zonal species (Kornaś 1955; Zając 1996; Zemanek, Winnicki 1999). However, its distribution within the compact range in Poland is diversified. Actually, its small share is noticeable in the Sudetes, and nearby plateaus and forelands (Danielewicz 2012). Fir aggregations are mainly found in the Carpathians, the Holy Cross region (*Góry Świętokrzyskie*) (Dziubałtowski 1928; Głazek, Wolak 1991) and the Roztocze region (Izdebski et al. 1992). At some places in the above-mentioned mountains and upland regions, fir aggregations comprise almost pure stands or mixed stands with other important forest canopy-forming species such as: beech, oak, hornbeam, pine, and spruce (Fig. 1).

The upper limit of the occurrence of fir is well documented, for example in the Tatras, where it reaches 1450 m a.s.l. (Komornicki 1974), the Bieszczady Mts. — 1260 m a.s.l. (Jasiewicz 1965; Zemanek, Winnicki 1999), the Beskid Żywiecki Mts., on Mt. Babia, or on Mt. Pilsko (Celiński, Wojterski 1978; Obidowicz 2004; Parusel et al. 2004). On the other hand, the lower limit of its range both in the mountains and in the foothills (Stachurska 1998), and especially in the uplands and in the lowlands is unclear and difficult to find. The reasons are: transformations of the primary forest areas into arable fields and on some areas, a very sharp reconstruction by forest management. As a re-

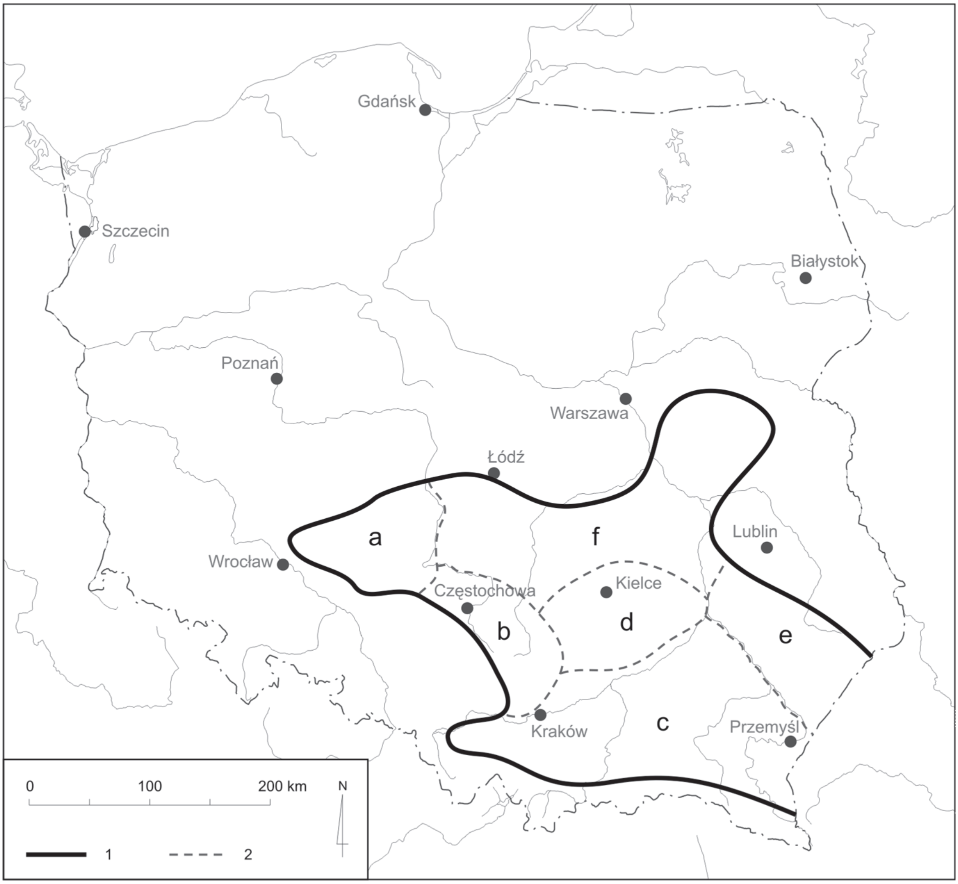

Fig. 1. Current distribution of the *Abietetum albae* association in Poland with proposed division into regional varieties: **a** — Silesian-Wielkopolska; **b** — Jurassic; **c** — Subcarpathian; **d** — Holy Cross; **e** — Roztocze; **f** — Mazovian

Explanations: **1** — borders of association's range; **2** — provisional borders of regional varieties

sult, the naturally composed multi-species forests have been transformed into those of one-species (monotypisation) and pine-dominated (pinetisation) forest stands (Matuszkiewicz J. 1977; Barć 2002, 2004; Brzeg, Rutkowski 2004; Danielewicz 2012; Matuszkiewicz W. et al. 2012).

Over the last few hundred years, the Sudetes have been logged heavily, and thus the area has been transformed due to the accumulation of a few settlement waves (Walczak 1968; Zientarski et al. 1994; Staffa 2001; Filipiak 2006). Forest cutting took place in the Sudetes as early as in the 13th century, because glass manufacturers began operating at that time. Despite that, the share of fir in some forests up to the middle of 18th century still achieved 10% (Zoll 1958). Nevertheless, because the fir as a species is sensitive to changes in its nearest environment (Filipiak 2006), it very quickly lost its important position in the species composition of the forest canopy in the Sudetes. Its role was taken over by spruce — a quickly growing species, which was planted into the forest phytocoenoses (Danielewicz 2012). Just before World War II, fir trees covered only 1—2% of the forest area; in the mid-1960s — 0.5% (Wilczkiewicz 1976); in 1978 — 0.4% (Zientarski et al. 1994) and in 1983 — only 0.2% (Boratyński 1983). The fir resources have been destroyed by the following factors: World War II, the wrong use of cultivation techniques after the war (it was treated the same way as spruce), the gradual extinction of the forest due to strong air pollution and the canopy opening as a result of the destruction of the forest stand by various natural factors (Zientarski et al. 1994).

The findings of contemporary studies indicate that in the past the fir was a common species at an altitudinal gradient of 350—800 m a.s.l. in the Sudetes and in their Forelands, while its share might have even been as high as 50—60% (Boratyński 1983). Actually, its vertical distribution is proportional to the share of forest area in particular zonal categories and is different in various ranges of the Sudetes. The latitudinal distribution of fir is of a directional character — the share of fir increases from NW to SE. The highest share of fir per area unit is found in the Bardzkie Mts., then in the Table Mts. (*Góry Stołowe*) and the Bystrzyckie Mts. (Filipiak, Barzdajn 2004).

During their inventory works in the Sudetes, Filipiak and Barzdajn (2004) identified 2 575 fir localities in total. Of the approximately 32 500 specimens that were later studied, the majority of them was created by specimens that were more than 50 years old. These grew on 2008 localities (the others were cultivations and up-growths). Fir trees most frequently occurred as scattered groups of specimens in small groups or as single trees. Only 5% of forest stands localities had a full density, 36% — a moderate density, and up to 59% — a loose density. Only 1% of the localities were covered by forest stands composed of more than 100 older trees (over 50 years old). One-fir localities comprised 12% of the inventory group, whereas localities with fewer than ten specimens comprised 63%. Fir trees occurred on slopes with different inclinations and exposures, usually in concave forms of the terrain. The most frequently occupied habitats were classified into a mixed mountain forest type site (an LMG type site — according to Polish classification system), which comprises the largest area in the Sudetes and then — a mountain forest type site (an LG type site), a mixed coniferous mountain forest type site (a BMG type site), an upland mixed forest type site (an LMwyż type site) or a coniferous mountain forest type site (a BG type site) (Boratyński, Filipiak 1997; Filipiak 2006).

Aggregations of fir trees in patches of a strongly transformed secondary community with a domination of spruce, were more similar to the coniferous communities than to the potential phytocoenoses of *Luzulo luzuloidis-Fagetum*. These untypical patches prevailed over typically developed *Luzulo luzuloidis-Fagetum* association phytocoenoses in the Sudetes. Moreover, fir occurred in the phytocoenoses of the *Galio sylvatici-Carpinetum betuli* and less frequently in the *Dentario enneaphylli-Fagetum*. It was also quite frequently recorded in patches similar to the *Abieti-Piceetum montanum* association and other communities from the suballiance of *Vaccinio-Abietenion*. It occurred sporadically in *Leucobryo-Pinetum* and *Calamagrostio arundinaceae-Quercetum*, as well as in a community from the suballiance *Cephalanthero-Fagenion* (Filipiak, Kosiński 2002).

Genetic studies indicate (Mejnartowicz 2000; Lewandowski et al. 2001) that the fir population in the Sudetes differs significantly from the Carpathian populations. It has a lower heterogeneity, but it is weakly diversified. This confirms its indigenous origin. At the same time, this poses a great challenge in relation to the restitution of *Abies alba* in the Sudety region because of the huge dispersion of small fir groups and single specimens of fir (Barzdajn 2000; Filipiak 2006).

The distribution of fir in the Carpathian arch results among others from the Holocene history of vegetation, which indicates that the lower mountain sites such as those in the Beskid Żywiecki Mts., the Podhale and the Tatras during the Subboreal period (5000—2500 BP) might have been covered with forests dominated by fir. The share of the species could have even been more than 54%. Based on the pollen diagrams, it has been proved that even later the quantitative dominance of fir over beech and spruce persisted up to the 19th century (Obidowicz 2003, 2004). At that time, in the Żywiec region (Western Galicia — *Galicja Zachodnia*), humans began the exploitation of primaeval forests by the so-called "clear cuttings" (Kawecki 1939). However, an analysis of the historical data revealed that in the Western Carpathians (*Karpaty Zachodnie*) in the 19th century, the stress must have been dependent on the specific forest management policy of each of the country's invaders (i.e., Austro-Hungarian and Prussian). Since the 18th century the natural forest vegetation of the Beskid Śląski Mts. and the Cieszyńskie Foothills have been under the influence of industrialized Silesia and have been much more transformed and devastated in comparison to the Galician forests. In practice, at the beginning of the 20th century, forest stands with a high fir share were not noted in the Silesian and the Cieszyńskie Foothills (Koczwara 1930; Pelc 1969). On the other hand, in nonindustrialized Galicia, conditions were favorable for the common occurrence of fir forests and fir-beech forests similar to those in other parts of the Carpathians (Strzelecki 1894, 1900; Wołoszczak 1897; Sosnowski 1925). To be precise, Hołowkiewicz (1877) named "the fir country" the area of deep forests between the Soła and the San rivers, but Wierdak (1927) significantly exceeded these borders by indicating the distribution of larger complexes of pure fir forests of natural origin in a large part of the Carpathian arch and the Carpathian Foothills within an area which belonged at that time to the Małopolska supraregion. These areas included fir forest islands east of the Biała (Bielsko town section) up to the Kołomyja in Pokucie (contemporary Ukraine). It was stressed by Wierdak (1927) that larger forest complexes with fir occurred in the Western Carpathians (*Karpaty Zachodnie*), whereas in the Eastern Carpathians (*Karpaty Wschodnie*) they were smaller and not as numerous. He also identified a general range of fir in the Małopolska supraregion, which was almost twice as large as the spruce range of natural origin at that time (Barć 2012).

Abies alba prefers deep, fertile and heavy soils that dominate in north-western part of the Carpathians and in the Beskid Sądecki Mts. (Ilmurzyński 1969; Włoczewski 1968; Jaworski 1973; Baran 1977; Jaworski, Zarzycki 1983). The significant contemporary role of forests with a higher share of fir (rarely pure fir stands) in the vegetation cover of the Polish part of the Carpathians is almost half of that (21% area of forests) of the share of beech (41%), but is still higher than spruce or pine of a secondary origin (Zięba 2010). Best maintained forest stands with fir in the Carpathians are actually found in the Beskid Sądecki Mts., the Beskid Niski Mts., the Przemyskie Foothills, and the Western Bieszczady Mts. (*Bieszczady Zachodnie*) (Białobok 1983; Przybylska, Kucharzyk 1999; Michalik, Pawłowski 2000; Przybylska, Zięba 2007). Forests in the Przemyskie Foothills and in the Beskid Niski Mts. (which are dominated by beech and fir) are distinguished by most diversified species composition, which is the result of the appropriate relationships between the forest canopy composition and an adequate habitat type. In the majority of cases these are mountain forests falling into forest site type: LG in the Carpathians and then mixed mountain forest (LMG type site), whose characteristic feature is the spatial variability of orographic and mesoclimatic local factors (Sikorska 1999; Przybylska 2003). Other types of habitats in forests such as a mixed upland forest type site (LMwyż type site), mixed coniferous mountain forest type site (BMG type site) or upland forest type site (Lwyż type site) occur rarely. However, considering the dominant structure of site types, forests dominated by fir from western and eastern parts of the Beskids (e.g., the Beskid Mały Mts. and the Beskid Niski Mts.) are similar in relation to that feature (Barć 2002, 2012; Michalik 2003; Przybylska 2003). It should be emphasized once again that their maintenance has been dependent on the history of forest management in particular areas.

Not only does fir create but also has an important share in the forest stands in the Carpathians and the Carpathian Foothills, among others in the following communities: the *Galio rotundifolii-Abietetum,* the *Galio-Piceetum*, the *Abieti--Piceetum (montanum),* the *Carici-Fagetum abietetosum* — a community from the *Cephalanthero-Fagenion* suballiance, the *Abietetum albae* (= *A. polonicum*), and the *Dentario glandulosae-Fagetum*. Moreover, it forms an admixture in the patches of the *Luzulo luzuloidis-Fagetum* and in the submontane altitudinal form of the *Tilio-Carpinetum*. The montane spruce forest on peat — the *Bazzanio--Piceetum* association — is one of the most interesting plant communities where fir trees were found as an admixture in the canopy and simultaneously in the lower layers of the forest. The community has been recorded in the Beskid Żywiecki Mts. (Kasprowicz 1996b), in the Beskid Śląski Mts. (Parusel 2001; Wilczek et al. 2015), and in the Beskid Mały Mts. (Barć et al. 2009).

The characteristics of particular syntaxa have usually been presented in regional studies — that is, for the Beskid Śląski Mts. — by Ludera (1965), Wilczek, Cabała (1989), and Wilczek (1995, 2006), or for the Beskid Mały Mts. — by Myczkowski (1958) and Barć (2012). Likewise, papers on the Beskid Żywiecki Mts. (dealing with Mt. Babia) — by Celiński and Wojterski (1978), Kasprowicz (1996a, b), and Parusel and others (2004), while papers dealing with the Polica Range by Stuchlik (1968). The vegetation of the Tatras has been characterised by the following authors: Szafer and others (1923), Myczkowski, Lesiński (1974), Matuszkiewicz J. (1977), Balcerkiewicz (1978), Balcerkiewicz, Pawlak (1978) and Wojterska, Wojterski (2004). The vegetation of the Pieniny Mts. has been described by Fabijanowski (1962), Pancer-Kotejowa (1973), Grodzińska (1975), while the vegetation of the Gorce Mts. has been studied by: Kornaś (1955), Medwecka-Kornaś (1955), Michalik (1967), Medwecka-Kornaś, Kornaś (1968), as well as by Denisiuk, Dziewolski (1985). The vegetation of the Beskid Sądecki Mts. has been characterised by Pawłowski (1925), Myczkowski, Grabski (1962), as well as by Staszkiewicz (1972, 1973). Studies concerning the Beskid Niski Mts. have been undertaken by Tacik and others (1957), Grodzińska, Pancer-Kotejowa (1965), Święs (1974a, b, 1982, 1983, 1985), as well as by Michalik (2003). Moreover, forests with a share of fir in the Polish Eastern Carpathians (*Karpaty Wschodnie*) (i.e., the High Bieszczady and Low Bieszczady Mts.) have been presented in papers by Zarzycki (1963), Dzwonko (1977, 1986), Zemanek (1981, 1992) or Michalik, Szary (1997). The vegetation of the Wielickie Foothills, in particular in its NE part, has been discussed by Stachurska (1998), while the Strzyżowskie Foothills have been studied by Towpasz (1990), as well as by Towpasz, Stachurska-Swakoń (2010). Moreover, general elaborations which depict Polish Carpathians, like that by Pawłowski (1977), have been written.

Carpathian forests with a significant share of fir are valuable remnants of fir-beech, beech-fir, and beech-fir-spruce forests of the former Carpathian Primaeval Forest. Some of them, especially those at an advanced age and with a differentiated and rich in species herb layer are protected in nature reserves (Rąkowski 2007).

The Holy Cross Mts. (*Góry Świętokrzyskie*) are the only area in Poland whose etymologically distinguishing name "The Fir Primaeval Forest" became syntaxonomically identified with *Abietetum albae* Dziubałtowski 1928 (= *A. polonicum* (Dziub. 1928) Br.-Bl. et Vlieg. 1939 *nom. illeg.*) despite significantly wider main range of this association in the country (Fig. 1). A mass occurrence of fir is conditioned by many factors there — that is, the relatively low elevation of the Holy Cross Mts. (approx. 300—600 m a.s.l.), a low orographic differentiation, lack of any significant altitudinal and latitudinal variability of the climatic conditions, high air humidity, high amount of annual precipitation, long terms of atmospheric silence and low wind speed (Kowalkowski, Jóźwiak 2000; Podlaski 2000). The unusually complicated geological structure of these mountains, which is reflected in its soil cover, is their specific feature (Olszewski 1992). Fir trees occupy lighter soils there than in the Carpathians. These soils are usually rich in water and are relatively fertile (Fabijanowski, Zarzycki 1965). The best forest stands of *Abies alba* within the area of the Holy Cross National Park (HCNP) (*Świętokrzyski Park Narodowy*) are on soils developed from silt and silty clay lying on stony and silty formations (Podlaski 2001). Głazek and Wolak (1991) distinguished three types (1—3) and some subtypes (a—d) of soils at HCNP. These were: (1) ground gley soils — (a) gley soils proper, (b) alluvial gley soils, (c) peaty gley soils; (2) brown soils — (a) grey-brown soils, (b) brown soils proper, (c) leached brown soils, (d) acid brown soils, and (3) grey-brown podzolic soils. Only a few of them are favourable to fir, especially biologically deep acid brown soils, leached brown soils, acid brown soils lying on quartzite, gleyed acid brown soils and peaty-gley soils.

Abietetum albae is a multi-layered community with several generations in the forest stand occurring in permanent ecological and topographical conditions. It is widespread in the Łysogóry Range within the borders of the Holy Cross National Park, in the Klonowskie Range and in the Wilkowska Valley, as well as in the Bielińskie Range, the Jeleniowskie Range, and in the foreland of the Holy Cross Mts. (Dziubałtowski 1928; Dziubałtowski, Kobendza 1933, 1934; Matuszkiewicz J. 1977; Głazek, Wolak 1991; Matuszkiewicz J. M., Kowalska 2007). Despite its typical shape, *Abietetum albae* (= *Abietetum polonicum typicum*), Głazek and Wolak (1991) have distinguished a degeneration shape of the association with *Pinus sylvestris* and "a community with *Dryopteris austriaca* with *Abies alba* share" and also *Tilio-Carpinetum abietetosum* and *Pino--Quercetum* with *Abies alba*. Moreover, fir as an admixture has been observed in the *Dentario glandulosae-Fagetum* phytocoenoses.

Wierdak (1927) wrote about the occurrence of fir in the Roztocze region. The region was treated as one of the thirteen "fir islands" that are located out of the compact range of the species in the Carpathians and the Carpathian Foothills. The species occurred there singly, in clumps, or as a dominant ones in the stands. The Beech Mountain (*Bukowa Góra*) nature reserve which included 117 ha of the area, was established a few years later (1934) on Zamojski's Property (*Ordynacja Zamojska*). It included the best maintained beech and fir forests. That reserve together with some others became the heart of the future Roztocze National Park (RNP) (Skuratowicz 1946; Skuratowicz, Urbański 1953; Fijałkowski, Izdebski 1959, 1972; Izdebski 1959, 1963; Wilgat 1994).

Within the borders of the Roztocze National Park (RNP), *Abietetum albae* covers almost 61% of the area occupied by coniferous mixed forests. It occurs on proper podzolic soils made of sands. Among the stands that are dominated by fir trees, the admixture is made by spruce, pine, and rarely beech. Fir regenerates well making new-growths and up-growths (beech-fir-spruce) that gradually achieve more advanced age classes. In other coniferous mixed forests of the RNP like: *Querco roboris-Pinetum* (next to spruce, birch, and aspen) and in *Querco-Piceetum* (next to oak and alder), fir occurs only as an admixture. *Abies alba* also plays the role of admixture in phytocoenoses of the *Dentario glandulosae-Fagetum* association — dense fir-beech forest with a participation of hornbeam, sycamore, maple, and spruce. It was observed in some places of the RNP that in the habitats of fertile beech forest, after they had been cut down, pure fir stands developed. In other places the extension of fir promoted pure beech stands. *Potentillo albae-Quercetum* is a light oak wood that is one of the most interesting, declining plant communities in this region, where a fir admixture has been observed as well (Wilgat 1994).

With the exception of *Abietetum albae*, a high share of fir is noticeable in the stand of the *Tilio-Carpinetum abietetosum* subassociation, which then physiognomically becomes more similar to *Abietetum albae*. However, silver fir also occurs as an admixture in typical and poorer, drier forms of oak-hornbeam-linden woods (Wilgat 1994).

The Cracow-Częstochowa Upland, otherwise known as the Polish Jura, has been inhabited as an upland area since the Palaeolithic. Since that time it has been more and more intensively used for agriculture and forestry. From the geomorphological point of view, this unique area became a particularly interesting object for studies on flora and vegetation (Berdau 1859; Medwecka-Kornaś 1952; Wika 1983, 1986, 1989; Babczyńska 1978, 1984; Brzeg, Wika 2011a, b; Urbisz 2004, 2008, 2012). In a relatively small space, sometimes on only one monadnock, there are numerous plant communities occupying completely different ecological niches, which is an important regional Jurassic specificity. At the same time, the Upland is an area where many mountain plant species occur.

The forest communities of the Cracow Jura, that is, the southern part of the Cracow-Częstochowa Upland, have been characterised by Medwecka-Kornaś (1952) in a preliminary study. However, among the syntaxa that were distinguished, fir occurred only as an admixture in forest stands of single patches of *Fagetum carpaticum*, *Querco-Carpinetum medioeuropaeum*, and *Acereto-Fraxinetum typicum*. Such a small share of this species was probably an effect of World War II, as well as of the disaster that was caused by the cold winter of 1928/1929, which was described by Paczoski (1929). Almost all of the fir trees in the Ojców Valley froze to death. In that context, the note of Professor Medwecka-Kornaś (1952) revealed the probable occurrence of the "remnants of a fir forest with *Lycopodium annotinum* and *L. selago*," which covered the slopes of the western exposure in the vicinity of the Dark Cave (*Grota Ciemna*) in the Ojców Valley, seems to be especially important. The author did not solve the problem, whether this was *Abietetum albae* following Dziubałtowski (1928) or a beech wood with a high admixture of fir. It is worth stressing that the share of fir was changeable, depending on the place where the forest occurred. This variability could refer to both a small (local) scale and to a larger (mesoregional) spatial scale (Medwecka-Kornaś 1952).

An acceptable thesis made a claim that an untypical borderland form of the *Abietetum albae* occurs in the Cracow-Częstochowa Upland (Matuszkiewicz J. 1977, Matuszkiewicz J. M. 2005). This association has not been documented widely enough to date back from this area despite many studies on the forest communities (Wika 1983, 1986, 1989). Hereźniak (1993), in his study (which was dedicated to the geobotanical-forest relationships of the northern part of the broadly approached Cracow-Silesian Upland) mentioned the locations of patches of this association among others from the Złoty Potok Inspectorate (the Dziadówki Forestry). Despite that, the central part of the Cracow-Częstochowa Upland remain documented only by his two phytosociological relevés. The fact that the photography of the physiognomy of the upland fir forest (Matuszkiewicz 1984) comes from the Kaliszak nature reserve, which is located in the northern part of the area studied, deserves attention. The main problem concerning identification of the patches of the upland fir forest was, and still remains, the influence of forest management that has transformed both the structure and species composition of the phytocoenoses and has even destabilised some features of the soil profile. The presence of patches of this association on quite numerous but rather small localities in the central part of the Cracow-Częstochowa Upland has been scarcely observed in the last decade.

Therefore, this book aims at providing characteristics of the *Abietetum albae* association in the central part of the Cracow-Częstochowa Upland, and in a particular way, it focuses on the following:
— the study and indication of its differentiation and regional peculiarity;
— the presentation of its distribution;
— the description of its local habitats;
— the discussion of the dynamics, regeneration, and the state of maintenance (current and potential threats and forms of protection) of the upland fir forest.

Alicja Barć

1. Physiographic characteristics of the study area

1.1. Location and borders

Studies on the upland fir forests were conducted in the central part of a specific macroregion — the Cracow-Częstochowa Upland. The study area is the same as in the case of the monographic studies by Wika (1986), as well as those of Brzeg and Wika (2011b). It covers an area of approximately 1500 km^2 (Fig. 2) and ranges between 19°10′ and 19°50′E and 50°15′ and 50°50′N. It is limited to Upper Jurassic quest from the West and the ravine of the Warta river near a town of Mstów in the North. Discontinous denudation threshold separates the Cracow-Częstochowa Upland from the Miechów Upland and the Nida Basin in the East. The line joining the localities such as Sułoszowa, Kosmołów, and Olkusz, forms southern border of the mesoregion (Fig. 2). The majority of the area is located within the Częstochowa Upland, although a part of it is located in the northern part of the Cracow Upland. These two mesoregions mentioned along with the Wieluń Upland comprise a macroregion 341.3 according to the classification put forward by Kondracki (2008), that is, the above-mentioned physical-geographic unit referred to as the Cracow-Częstochowa Upland. In the past it was also called the Cracow-Wieluń Upland (Michalik 1974) or briefly — the Cracow Upland (Wika 1986).

1.2. The most important information concerning the natural environment

The Cracow-Częstochowa Upland is a well-defined geobotanical, physiographic, natural, historical, and cultural unit (Stefaniak et al. 2009; Brzeg, Wika 2011b).

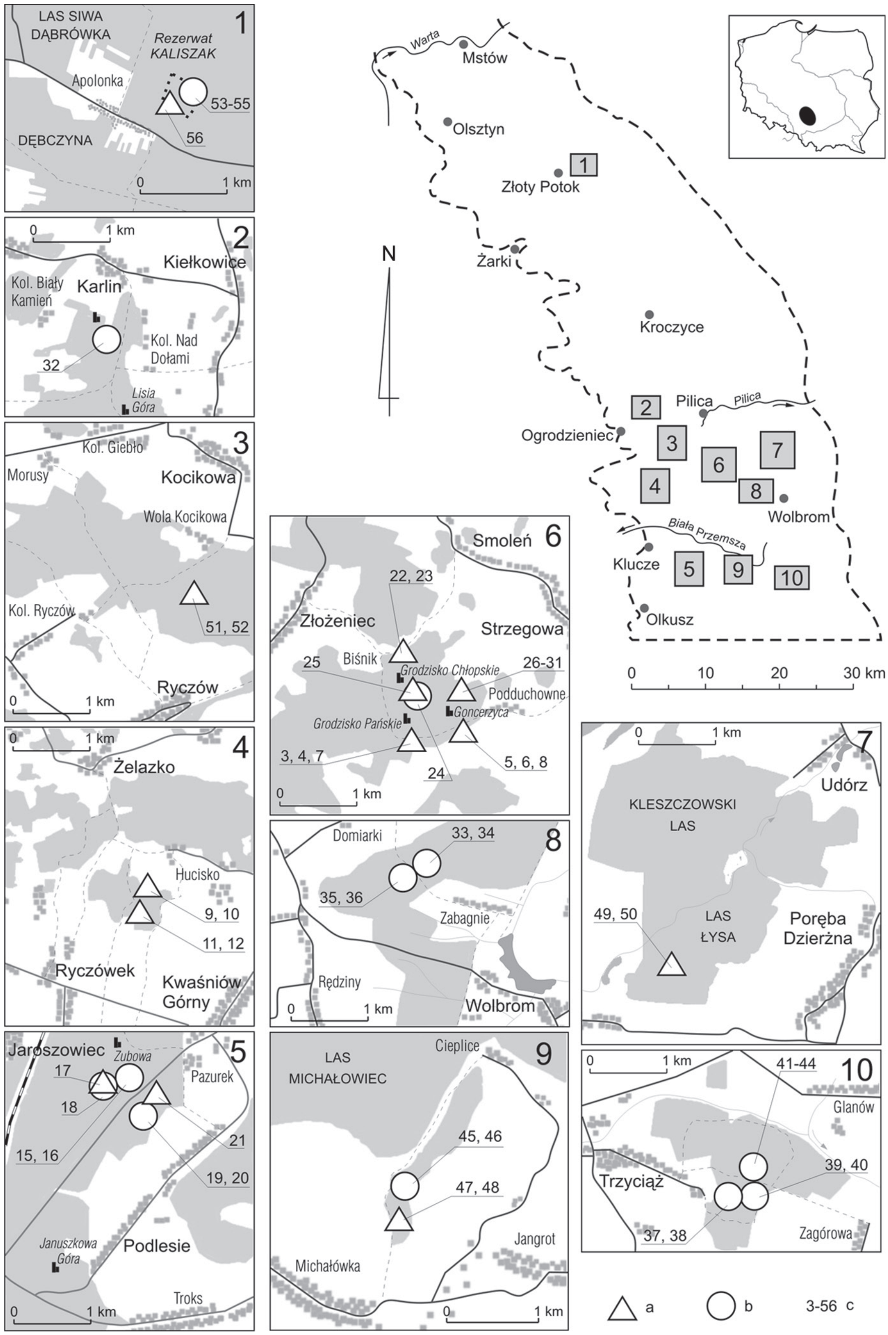

FIG. 2. Distribution of localities and analysed patches of the *Abietetum albae* in the area of the central part of the Cracow-Częstochowa Upland

Explanations: 1—10 — localities of the association, **a** — locations of patches of the *A. a. circaeetosum alpinae*, **b** — locations of patches of the *A. a. typicum*, **c** — numbers of phytosociological relevés

Limestone monadnocks that are covered with high vegetation are in the majority — that is, various species of trees and shrubs are quite noticeable in the Jurassic landscape. The edges of the mesophilous woods, mainly beech and hornbeam--oak-linden forests, as well as thermophilous shrubs from the *Rhamno-Prunetea* class (including gaps) are covered with some fragments of xerothermic grasslands that are still maintained. These communities were much more widespread in the past than they are today (Babczyńska 1978; Babczyńska-Sendek 1984; Wika 1986; Michalik 1990). Nowadays, as a result of natural succession after the abandonment of pasturage and mowing (other extensive but regular shaping factors), these communities have undergone a transformation from the *Trifolio--Geranietea sanguinei* class into thermophilous tall-herbs. Their life-cycle is short. Over several years of resistance, they transformed into shrubs and then — for better or for worse — forest communities developed.

The specific feature of the described (central) part of the Upland is the high variability and mosaic of the habitats connected with the rich relief of the area and its geology, the different exposures of rocky walls, a variety of depths and fertilities of soils, and a unique topoclimate. Therefore, species that represent various scale of ecological tolerance can grow close to each other. Rocks of the Jurassic period, which have slopes exposed in such a way, can only be found in this macroregion (Tyc 1994).

The area of central part of the Cracow-Częstochowa Upland belongs to climatic district of Częstochowa—Kielce (Zinkow 1988; Tyc 1994; Kondracki 2008). The climate of this region is colder when compared to the Silesian Upland and the Miechów Upland. It is characterised by higher precipitation (from 600 to 850 mm per year, 712 mm on average). Mean annual temperatures on the borders range from +7°C to +8°C. Microclimatic differentiation is higher than topoclimatic (Michalik 1974; Urbisz 2008). Vegetation period lasts 200—210 days. Western and southern winds prevail, which is not favourable for vegetation. They bring dust and poisonous gases from industrial city centres of the region (Zawiercie, Ogrodzieniec, Klucze, Olkusz) and strongly polluted air from the Upper Silesian Industrial District as well (Wika 1978).

The monadnocks are composed of whiter, softer, and strongly cracked lower rocky limestone, and a hard, upper rocky limestone of light-grey colour that is resistant to eolic erosion, which is the basic material of the rocky forms (Dżułyński 1952; Szaflarski 1955; Heliasz 1991; Nita 1992). The monadnocks occur in this area singly or in groups that comprise the so-called "mount deposits"; more often, however, they comprise chains that are a few or over several (and even longer) kilometres long. Their tops are often very picturesque and have unusual shapes; therefore, this part of Poland can boast so many unique landscape values.

In the central part of the Cracow-Częstochowa Upland, limestone monadnocks reach altitudes ranging from 300 to 515 m a.s.l. Today, *Góra Janowskiego* is acknowledged as the highest upland elevation in Poland (Urbisz 2004, 2008). However, not only Jurassic structures are important elements in the Cracow--Częstochowa Upland's landscape. Sands, which have been deposited on the bottoms of almost all of the depressions, should be mentioned here, as well as loesses and structures that are similar to loesses covering gently inclined areas (Michalik 1974; Wika 1986). Both of these loose sedimentary rocks come from the upper Pleistocene and Holocene periods. The sands are differentiated according to their age and genesis. They can be divided into proper forming sands, postglacial sands, sands of a river origin, and dune-forming sands. Their particular characteristic features are presented by Szczypek (1986).

The presence or absence of one of the three main basic rock types (Jurassic limestones, loesses, and sands) means that various mineral soils can be recognized as distinct. Depending on the quantitative share or on the lack of one of the three components mentioned in this part of the Jurassic area rendzinas, pararendzinas, brown soils, grey-brown podzolic soils, podzolic soils, and ground gley soils can be distinguished. Mud soils, slime-marshy soils, and peaty soils were noted in the river valleys and in depressions with high ground water level. Their structure, as well as high mosaic and biological abilities, have attracted the attention of a few scientists: Musierowicz (1961), Kobyłecka (1981), and Adamczyk, Kobyłecka (1980, 1982).

Another feature of the area studied is water shortage, resulting from watershed location and its drainage by both surface flow and underground flow (Wika 1986). The characteristic features of weather conditions are frequent heavy rainfall with hailstorms and strong thunderstorms, and also significant differences in the temperature between neighbouring towns and villages (Tyc 1994).

Brzeg and Wika (2011b) wrote more about the state of preservation of the plant cover in this area after their phytosociological studies on xerothermophilous tall herbs. Their detailed studies permitted not only a few Jurassic geographic varieties to be distinguished, but also plant associations that were new to Poland, new subassociations and many units of a lower rank, which are vicariants with similar units, known from other parts of the country (Brzeg, Wika 2007, 2011a, b).

Actually, afforestation differs depending on the locality from 0 to 10% near Cracow to 20.1—30% near Częstochowa. Typical arrangement of forest communities indicates bottom (in valleys) or lower position on a slope in case of pine or mixed pine-oak forest and upper and top position of beech woods of different types (e.g. Carpathian acid, orchid). Fir, hornbeam, oak, and linden make frequent admixture in beech woods; rarely do they create separate community with hornbeam domination. Spruce occurs as artifitial admixture. Sycamore forests *Phyllitido-Aceretum* with hart's tongue fern (*Phyllitis scolopendrium*), belong to one of the most interesting forest communities (Bodziarczyk, Malik 2006; Wika, Barć 2011). The oldest (Vth, VIth age classes) and the best maintained forests are protected in numerous reserves (e.g. The Sokole Mts., Parkowe), (Rąkowski 2007), but significant areas are covered by forests of secondary origin and at lower age classes (I—IV). It is worth mentioning that health state of Jurassic forests depends not only on their character (primary, secondary), but also on ownership (State Forests, private forests), usage (degeneration stages), and also air pollution, as well as on soil and water (surface and underground) contamination. Jurassic forests are surrounded by large industrial centres — that is, by agglomerations, such as Cracow and Katowice, as well as smaller towns like Częstochowa. All of the above are sources of SO_x, NO_x, heavy metals and other pollutants (Medwecka-Kornaś, Gawroński 1993). Numerous smaller factories, coal and ore mines, ironworks, influence the state of maintenance of forest in the local scale.

The number of taxa (1433) expresses the full richness of the vascular flora found in the entire area of the Cracow-Częstochowa Upland (Urbisz 2004, 2008, 2012). Among the 1225 species of vascular plants that were recorded in the central part of the upland (Wika 1986), *Cochlearia polonica*, *Galium cracoviense*, *Potentilla silesiaca*, and *Larix decidua* ssp. *polonica* are endemic species which require special attention. *Cochlearia polonica* that was restituted among others in the Wiercica River Valley (Celiński, Wika 1981) is an endemite of Pleistocene origin (Szafer, Zarzycki 1977). It is actually called a narrow-endemic taxon (Cieślak et al. 2010). Similarly, *Galium cracoviense* has the status of Pleistocene endemite, a taxon that was recognised by Kozłowska (1928), and studied, among others, by Kucowa (1962), Babczyńska (1978), and other researchers, which has been lately confirmed by Karaśkiewicz (2007) on the basis of 15 hills that surround the small town of Olsztyn near Częstochowa. The subendemite status of south-western Poland has *Potentilla silesiaca* occurring only on Luminous Mountain (*Jasna Góra*) in Częstochowa and on the hills that are called Towarne Mts. (Kusięta village near Olsztyn). *Larix decidua* ssp. *polonica*, previously known as *Larix polonica,* is an endemite to Poland and the Carpathians with its main distribution centre located in the Małopolska Upland (*Wyżyna Małopolska*) (Szafer, Zarzycki 1977; Hereźniak 1996, 2004; Babczyńska-Sendek et al. 2006). Mountain species (61 taxa) and 191 species that reach the limit of their range in the area studied comprise an important group in the Upland area (Wika 1986; Urbisz 2008).

2. Material and methods

Studies on the *Abietetum albae* association, which were conducted in the central part of the Cracow-Częstochowa Upland, included study localities, where phytosociological relevés, soil profiles, as well as studies on the structure of the forest stands and the dynamics of the regeneration of trees were done with particular attention being paid to the fir. Some part of these studies was conducted on permanent study plots. The location of the study plots and the elevation of the terrain was measured with a GPS Garmin and localized on the map with a scale of 1:52 000 entitled "The Cracow-Częstochowa Jura."

The material used for the regional geobotanical characteristics of the *Abietetum albae* association in the area studied consisted of 52 original phytosociological relevés compiled in analytical tables (Tables 3 and 4), as well as in a general synoptic table (Table 5, col. 7 and 11). Phytosociological relevés were made by using the Braun-Blanquet method (Braun-Blanquet 1964; Pawłowski 1972) during the optimum period of the vegetation seasons in 2009 and 2011 on the area of relevés covering 200—400 m^2. Relevés were made within the fir forests that were found in areas that had been identified earlier during studies on hart's tongue (*Phyllitis scolopendrium*), (Wika, Barć 2011) and thermophilous tall herbs (Brzeg, Wika 2011a, b), and in new phytocoely discovered phytocoenoses with a high share of fir, which together comprised ten clearly identified localities (Fig. 2). The rule of the well-maintained homogeneity of the patches studied was applied. All patches were also representative of the entire phytocoenose that was studied and for the preliminarily diagnosed syntaxon at the rank of a subassociation or association. Small-scale spatial studies on the regeneration of fir were performed on permanent plots (Fig. 3).

All of the relevés were then compiled in a preliminary table and, afterwards, they underwent a numerical analysis (cluster analysis) by using the STATISTICA 8.0 program, after former transformation the basal data using the following formula: r = 1, + = 2, 1 = 3, 2 = 5, 3 = 7, 4 = 8, 5 = 9 (van der Maarel 1979). The aggregation of objects was done by using minimum variance method

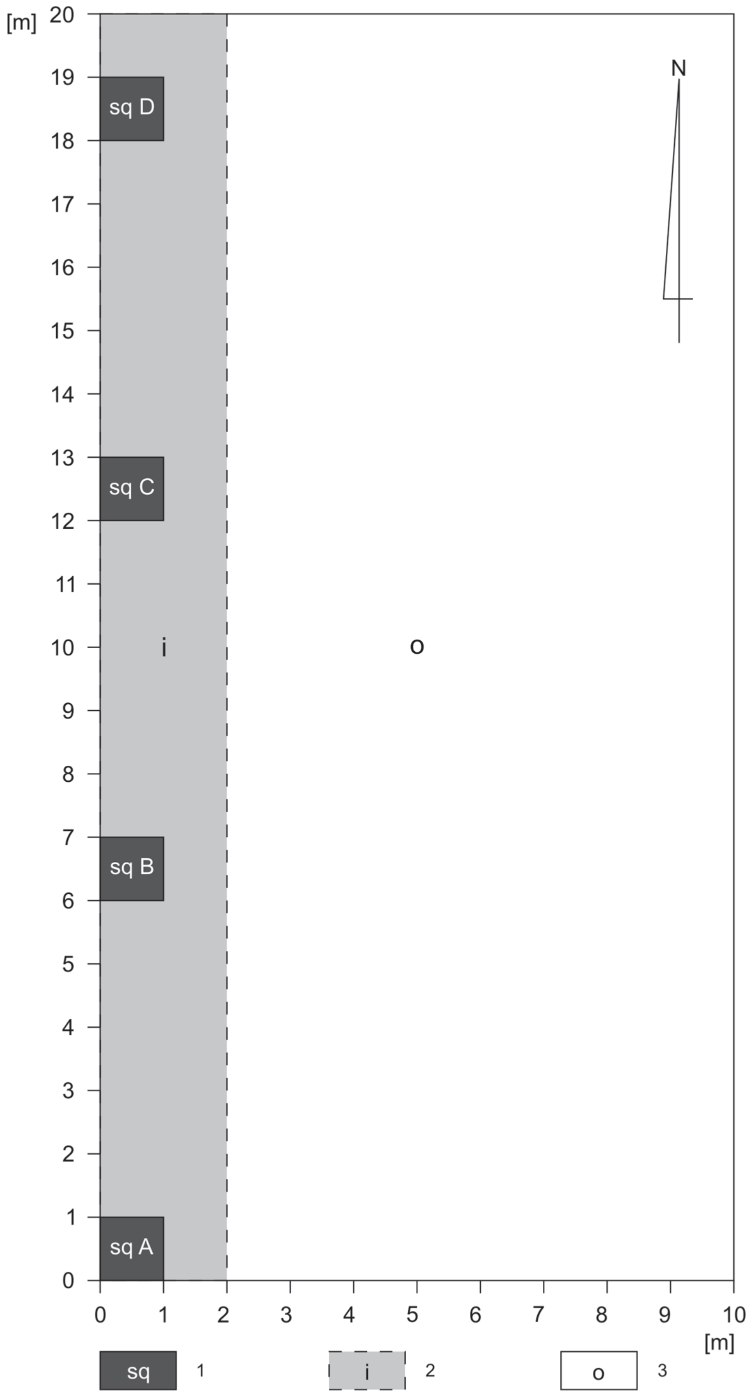

FIG. 3. Scheme of the division of each of the study plot (I—VI)

Explanations: **1** — square 1 m × 1 m; **2** — inner subarea "i" 2 m × 20 m; **3** — other subarea "o" 8 m × 20 m

(Ward method), and the Euclidean distance was taken as the similarity coefficient. The analysis of floristic differentiation of the studied patches of the fir forests was made according to DCA method (detrended correspondence analysis), by using the package CANOCO for Windows (Hill, Gauch 1980; ter Braak, Šmilauer 2002), along with the transformation of basal data mentioned above. The dendrogram (Fig. 4) and the arrangement of particular phytosociological relevés according to DCA analysis (Fig. 5) influenced the final ordination of the collected material in the two phytosociological tables to a significant degree. These tables document units in the subassociation rank (*Abietetum albae typicum* and *A.a. circaeetosum alpinae*) and in the case of the first of these they also illustrate the differentiation into two variants that have been distinguished (van der Maarel 1980).

The original data from the central part of the Cracow-Częstochowa Upland were compared with others that came from different parts of Poland within the range of the fir forests in order to confirm any regional uniqueness of the *Abietetum albae* association in the Jurassic region. The results are included in the general synoptic table (Table 5). This table, which consists of 34 columns, compares 733 phytosociological relevés created by different authors, which are treated in units of the subassociation rank as proposed by Matuszkiewicz J. (1977). Other materials have been previously diagnosed and divided into subassociations by the authors of the presented elaboration.

The syntaxonomic classification and diagnostic role of plant species was taken after Matuszkiewicz J. (1977), taking into consideration the modifications and nomenclature changes that were proposed by Ratyńska and others (2010), as well as some supplements, which resulted from the original studies. These follow the rules of the International Code of Phytosociological Nomenclature (ICPN, Weber et al. 2000).

The taxa names of vascular plants were based on Mirek and others (2002), mosses were based on Ochyra and others (2003), while the names of liverworts were taken after Grolle and Long (2000).

Three soil profiles were dug up in order to compile a more detailed documentation in which the soil conditions of the phytocoenoses of the *Abietetum albae* association in the Jurassic area developed. These three soil profiles were dug up in places where three earlier phytosociological relevés with field numbers: 6, 12, and 40 were made. Moreover, the profiles neighboured three (i.e. I, III, and V) from among six permanent study plots that are to be the subject of studies on the structure and dynamics of the fir stands located within the patches of previously made phytosociological relevés. Two of the soil profiles were localized within the patches of the *A.a. circaeetosum alpinae* subassociation (Goncerzyca Rock in the Wodąca River Valley, field relevé no. 6, and to the west of Mt. Rząsowy (*Góra Rząsowy*) near Hucisko Ryczowskie, relevé no. 12), while one profile was located in the *A.a. typicum* subassociation (Trzyciąż, field relevé no. 40) to the south of the Trzyciąż—Zagórowa road.

Small-spatial scale studies on permanent plots (I—VI) were conducted in April and May of 2011. These focused on three study localities: Strzegowa Poduchowne (Goncerzyca Rock), Hucisko Ryczowskie, and Trzyciąż. The exact locations of the permanent plots are presented in table below (Table 1).

Table 1. The set of permanent study plots of the *Abietetum albae* association in the central part of the Cracow-Częstochowa Upland

No. of study plot	Locality (study plot)	Commune	GPS coordinates for I—VI	Altitude a.s.l. [m]
I	Strzegowa Poduchowne (Goncerzyca Rock)	Strzegowa	N 50°25′322″ E 19°40′520″	449
II	Strzegowa Poduchowne (Goncerzyca Rock)	Strzegowa	N 50°25′371″ E 19°40′533″	427
III	Hucisko Ryczowskie	Klucze	N 50°23′990″ E 19°34′490″	425
IV	Hucisko Ryczowskie	Klucze	N 50°23′975″ E 19°34′462″	427
V	Trzyciąż	Trzyciąż	N 50°18′386″ E 19°47′684″	417
VI	Trzyciąż	Trzyciąż	N 50°18′374″ E 19°47′672″	415

The odd-numbered permanent study plots (I, III, V) were spatially connected with a phytosociological relevé and soil profile; the other even-numbered permanent plots (II, IV, VI) were outside of phytosociological relevés where soil profiles were not dug. The permanent plots were stabilised with wooden sticks and surrounded by measuring tapes and lines.

On each permanent plot of rectangular shape (Fig. 3) of 20 × 10 m (200 m^2), the diameter at breast height (dbh) was measured twice in order to measure all of the components of the **tree layer** in the N-S and E-W directions (most of the analysed forest is of private property and represents Vth age class). The mean values, which resulted from two measurements, were used in counting. This was because in the majority of cases the trunks of the trees had an irregular shape. Specimens that reached or grew higher than eight metres in height and had more than eight centimetres of dbh were identified as trees. The dbh was measured at height of 1.3 m, using a Sandvik's measuring diameter slider. When the tree was more than 50 cm in the diameter — its circumference was measured by the use of a measuring tape, and the results were calculated into the diameter dimension. Then, any lack of information concerning the real shape of the tree trunk in the case of really large fir trees was calculated. Dbh measurements were made within a 0.5 cm precision. These measurements permitted the fir stands together with admixtures to be characterised according to: the number of trees, species richness, the dbh distribution in the following thickness classes: uneven class 8—9 cm (makes it possible to identify the youngest tree generation) and in the following categories reckoned each 5 cm: 10—14 cm, 15—19 cm, up to 55—59 cm. In the case of two of the permanent study plots from Trzyciąż, additional categories were also taken into consideration: 70—74 cm and 95—99 cm. Mean values that were higher than the maximum of the thickness classes were included into a given category (e.g., 19.5 was included into 15—19 cm thickness class). For comparison purposes, the results of measurements in 10 cm thickness classes were used in the following categories: 10—19 cm up to 90—99. Then, the range of diameters that measured 10—99 cm (i.e., out of the uneven class of 8—9 cm) was divided into three equal subranges including: low (10—39 cm), medium (40—69 cm) and high (70—99) diameter values. The use of the three aforementioned diameter classes made it easier to compare the data presented here with the results achieved by other authors.

A mixed height-thickness scale was used for measurements of the heights and diameters of **up-growths**. Within each of the permanent study plots a delimited "internal" subarea "i" 2 m × 20 m (40 m^2) and a subarea "o" like "other" were created. All up-growths were measured within both subareas independently. After the preliminary counting, due to the low number of up-growths in the "internal" subarea, the total number of up-growths was finally given for "i" and "o" areas together, which means for 200 m^2 (2 ares; in total for 1200 m^2, 12 ares). However, for comparison purposes, the data from both subareas have been compiled in the chapter where the results of these studies have been presented, and then discussed in another chapter. The measurement of the diameters of up-growths up to 0.5 cm usually revealed specimens that were not higher than 1.3 m and that were made with 0.1 cm precision at the half height of the specimen. In the case of larger individuals, the measurement was taken at a height of 1.3 m with the precision of 0.5 cm up to a diameter value equal to 7.99 cm. The obtained results were aggregated in the following classes of thickness: 0.1—1; 1.1—2; 2.1—3; 3.1—4; 4.1—5; 5.1—6; 6.1—7, 7.1—7.99 cm. Specimens that had reached and exceeded a height of 0.5 metres and still had not reached eight metres in height were identified as up-growths. The specimens that were measured were aggregated into the following height classes: 0.5—1.0; 1.1—1.5; 1.6—2; 2.1—3; 3.1—4; 4.1—5; 5.1—6; 6.1—7; 7.1—7.99 m.

Studies of **new-growths** within the permanent plots were conducted in four 1 m × 1 m squares that were called study units (4 m^2 in total per one plot), which were demarcated in each of six permanent study plots (I—VI). The squares were marked within the internal subarea "i," which had been delimited for the studies of up-growths and that was situated along the twenty-metre-long edge of the plot, always at the same position: 0—1 m (A square), 6—7 m (B square), 12—13 m (C square) and 18—19 m (D square). Squares A, B, C, and D together comprised the study unit for new-growths (Fig. 3). New-growths of trees and shrubs were numbered and their height was measured with 0.5 cm precision. The values of the new-growth heights were aggregated in the following height classes: 0—5; 5.1—10; 10.1—15; 15.1—20; 20.1—25; 25.1—30; 30.1—35; 35.1—40; 40.1—49.9 cm. Moreover, the total percentage of the herb layer cover and particular species, which were the components of that layer was fixed. The total cover of the moss layer was also ascertained, but without determining the particular moss species.

3. Geobotanical characteristics of the *Abietetum albae* association

3.1. General characteristics

Patches of the *Abietetum albae* association from the central part of the Cracow--Częstochowa Upland in general are of the type characterised by Matuszkiewicz J. (1977) as an upland fir mixed coniferous forest, under the name the *Abietetum polonicum* (Dziub. 1928) Br.-Bl. et Vlieg. 1939. That hypothesis was confirmed by both the forest stand, which is dominated by *Abies alba* (see further chapters) in the majority of the phytocoenoses that were studied, as well as in the general oligo-mesotrophic and moderately acidophilous character of the entire floristic composition of the association and habitats studied. These habitats have a medium character between a fresh coniferous forest from the *Dicrano-Pinion* alliance (see Wika 1983) and beech woods from the *Fagion sylvaticae* alliance. Some relationships with oak-pine mixed coniferous forests, acidophilous oak woods, or occasionally hornbeam-oak-linden poor deciduous forests were also observed.

The nomenclatural type of association (lectotype) was delimited by Brzeg and Rutkowski (2004, 83). It is the 16th phytosociological relevé from Table 5, which is derived from the original diagnosis made by Dziubałtowski (1928).

The structure. The multi-layered structure of the majority of patches was very differentiated. Most often fir trees dominated in the stand. The heights always varied, at least on two clearly visible sublevels. These sublevels often include wide ranges of heights; therefore, there are no clear borders from the other layers of the forest. The upper sublevel (a_1) reached 25—36 m in height and had a density of 40% (exceptionally) up to 80% (mean approx. 65%). The lower sublayer (a_2) reached heights of more than 8 m up to approximately 20 m, and had a more changeable density (10—60%, mean approx. 29%). The high density of the tree crowns meant that the fir phytocoenoses were shadowed and sometimes even dark, so they were a bit similar to mountain or boreal coniferous spruce forests.

The shrub layer (b), with up-growths that were up to 8 m high, was always present but had developed to various degrees. It reached a density from imperceptible to 30% (mean approx. 12%). It usually developed in small clusters and was present in lighter places (mainly within gaps or in the vicinity of gaps in the forest stand).

The herb layer (c) reached a cover of 15% up to 80% (mean approx. 43%). It often had a mosaic, cluster or clumpy structure and varied in height. Middle-high thickets and herbs and some vascular plants grow next to high clumps of ferns, and for example, *Circaea alpina*, *Galeobdolon luteum*, or *Oxalis acetosella* grow very close to the ground.

The moss layer (d) was always present and had very different cover levels ranging from insignificant to 75% (mean approx. 17%). Plagiotropic species prevailed in that layer.

Occurrence conditions. The *Abietetum albae* phytocoenoses in the study area occurred in classical upland conditions. They developed in an altitude range from 278 m a.s.l. (exceptionally) up to 460 m a.s.l., and most frequently between 380 and 420 m a.s.l. Most frequently they were situated on slopes of various exposures and with a mean inclination of approximately 7.5° (2—20°), and rarely in flat places. They usually occurred in the lower parts of the Jurassic slopes.

Based on three soil profiles, soils that were under the cover of fir forest habitats have been studied (Table 2). They were diagnosed as grey Luvisols or deficient, weakly developed grey Luvisols formed of sandy loams or silty clays lying on compacted silty clays that had been deposited on deeper lying Jurassic limestones. Horizon A_1 is located at a depth of one to twelve centimetres, and above it a humus horizon of a moder type (A_0) is situated, which is zero to five centimetres thick and not completely decayed. The flow horizon (A_3) had a mechanical composition of sandy silty clay, and was not distinct or clear, and in profiles reached a depth of 5—39 cm.

The reaction of pH in the surface horizons was weakly acidic or acidic: in A_0 3.88—5.93 in H_2O (2.91—4.78 in KCl), while in A_1 — 3.72—5.05 in H_2O (2.90—3.70 in KCl). The deeper the profile, the weaker the acidity of these soils was. $CaCO_3$ was absent along the entire profile in all three soil profiles.

Similar grey Luvisols that are formed of heavy deposits were observed in the majority of the other fir phytocoenoses of the *Abietetum albae* association in the Jurassic area. However, it should be stressed that in some cases, like for example, in the Black Forest near the village of Wola Kocikowa (rel. 25 and 26 in Table 4) coniferous fir forests were also observed on rusty soils, which had developed from sandy deposits. Regarding humidity, all of the habitats (sites) of the *Abietetum albae* association can be described as fresh (locally strongly fresh in transition to wet, see Matuszkiewicz J. 1977 and Matuszkiewicz J. M., Kowalska 2007).

Table 2. Chosen properties of soil in the *Abietetum albae* patches in the central part of the Cracow-Częstochowa Upland

Sample no.	Depth [cm]	Horizon	pH in H_2O	pH in KCl	Conductivity [mS/m]	$CaCO_3$	Mechanical composition	Colour	Transition
Profile 1: *Abietetum albae circaeetosum alpinae*									
Location: Strzegowa Poduchowne (Goncerzyca Rock), 449 m a.s.l., N 50°25′336″ E 19°40′503″, rel. 6									
1.	0—1	A_0 moder	4.93	3.81	246	lack	—	rusty-brown	—
2.	1—5	A_1	4.37	3.05	98	lack	compacted sandy loam	blacky-grey	soft; damp patches
3.	5—30	(A_3)	4.54	3.52	21	lack	sandy silty clay	light-beige	gradual
4.	30—35	B_T	5.16	3.67	16	lack	silty clay	beige	distinct
5.	35—130	C	5.11	3.57	14	lack	silty clay	brick-red-beige	distinct
6.	> 130	D	5.16	3.67	—	lack	compacted silty clay	beige-yellow	distinct
Diagnosis: deficient grey Luvisol									
Profile 2: *Abietetum albae circaeetosum alpinae*									
Location: Hucisko Ryczowskie, 425 m a.s.l., N 50°23′978″ E 19°34′489″, rel. 12									
7.	0—4	A_0 moder	5.93	4.78	443	lack	—	blacky-brown	—
8.	4—11	A_1	5.05	3.70	42	lack	compacted sandy loam	grey-black	soft
9.	11—29	(A_3)	4.81	3.72	34	lack	low sandy silty clay	light-beige	soft
10.	29—140	C	4.66	3.51	28	lack	silty clay	beige-brown	soft
11.	> 140	D	5.08	3.61	23	lack	strongly compacted silty clay	beige-brown	distinct
Diagnosis: deficient weakly developed grey Luvisol									
Profile 3: *Abietetum albae typicum*									
Location: Trzyciąż, 417 m a.s.l., N 50°30′698″ E 19°79′482″, rel. 40									
12.	0—5	A_0 moder	3.88	2.91	—	lack	—	brown	—
13.	5—12	A_1	3.72	2.90	—	lack	clay	black	gradual
14.	12—39	A_3	4.11	3.82	—	lack	sandy silty clay	beige	gradual
15.	39—53	B_T	4.14	3.97	—	lack	compacted silty clay	dark-beige	gradual
16.	53—88	C	4.17	3.75	—	lack	loose silty clay	beige-brown	distinct
17.	88—130	D	4.85	3.88	—	lack	silty clay	beige-rust	distinct
Diagnosis: deficient grey Luvisol									

According to the forest-site typology, the coniferous fir phytocoenoses (Trampler et al. 1990; Bańkowski et al. 2004; Rutkowski 2012; see also Brzeg, Rutkowski 2004; Barć 2012) developed on the upland mixed coniferous forest habitat (upland mixed coniferous forest type of site) and at least a few patches of the more fertile *Abietetum albae circaeetosum alpinae* on the upland mixed deciduous forest habitat (mixed upland forest type of site).

3.2. Floristic composition, local-habitat differentiation, and distribution in the study area

Floristic composition. The occurrence of the *Abietetum albae* association in the central part of the Cracow-Częstochowa Upland has been documented with 52 phytosociological relevés (Tables 3 and 4; Table 5, col. 7 and 11). The association that was studied has been acknowledged as a rich syntaxon as to its floristic features. The number of species per one patch has changed from 29 to 63 in relation to the entire association with a mean value equal to 43. A total of 171 taxa of vascular plant species and mosses was recorded, including 83 that reached II—V constancy degrees on at least one of the distinguished subassociations.

The forest stand, most of all, comprises silver fir *Abies alba*. In general, it is well regenerated in all forest layers although there are some exceptions (see Chapter 4). A frequent admixture was spruce *Picea abies*, which in some localities even played a dominant role. Spruce was also quite a dynamic species in the lower layers of the forest. Birch *Betula pendula*, beech *Fagus sylvatica*, oak *Quercus robur*, and pine *Pinus sylvestris* belong to an admixture species that was quite frequent in the stand, and in a lower sublayer (a_2) rowan *Sorbus aucuparia* was observed. The other species of trees that were represented in the phytosociological relevés (*Acer pseudoplatanus*, *Betula pubescens*, *Fraxinus excelsior*, *Larix decidua*, *Populus tremula*, *Quercus petraea* and others) were observed only sporadically. It is noticeable and worth underlining that the presence of many species of trees, including deciduous ones, strengthened the "mixed" and simultaneously "upland" character of the entire species arrangement.

In the shrub layer, *Corylus avellana*, *Frangula alnus*, and *Sambucus racemosa* often occurred next to the up-growths of the above-mentioned species of trees (rowan, fir, and spruce mainly). Other species that were recorded appeared only sporadically.

Ferns (*Athyrium filix-femina*, *Dryopteris carthusiana*, *D. dilatata*, *D. filix-mas*), bilberry *Vaccinium myrtillus*, raspberry and brambles (*Rubus idaeus*, *R. hirtus* and *R. pedemontanus*), numerous herbs (*Maianthemum bifolium*, *Mycelis muralis*, *Oxalis acetosella*, *Senecio ovatus*, *Trientalis europaea*, and others), as well as wood-rushes, grasses, and sedges (*Luzula pilosa*, *Agrostis capillaris*, *Calamagrostis epigejos*, *Deschampsia flexuosa*, and *Carex pilulifera*) belong to a relatively constant and, for the most part, numerously growing species of the herb layer. Many other taxa were observed somewhat rarely. These occurred with a higher constancy only in the delineated shape of the association (e.g., *Galium odoratum*, or *Gymnocarpium dryopteris* occurred in a more fertile subassociation).

A total of 30 taxa of mosses and liverworts were observed in the moss layer. The most important among them were: *Atrichum undulatum*, *Brachytheciastrum velutinum*, *Dicranella heteromalla*, *Hypnum cupressiforme*, *Plagiomnium affine*, *Plagiothecium curvifolium*, *Pleurozium schreberi*, *Pohlia nutans*, *Polytrichastrum formosum*, *Sciuro-hypnum oedipodium*, and *Thuidium tamariscinum*.

A phytosociological diagnosis of the association revealed good representation of characteristic and differential species for particular syntaxa of the hierarchic system: association — suballiance — alliance — order/class. Species that have been acknowledged as regionally characteristic for the association (*Abies alba*, *Dryopteris dilatata*, and *Thuidium tamariscinum*) (see Matuszkiewicz J. M. 1977, 2005; Brzeg, Wojterska 2001; Matuszkiewicz W. 2001; Ratyńska et al. 2010; Matuszkiewicz W. et al. 2012), as well as some that differed within the suballiance (*Atrichum undulatum*, *Rubus hirtus*, *R. pedemontanus*, and *Sambucus racemosa*) were constantly or often present. Only *Cruciata glabra* was more weakly represented from this group of species, despite the fact that it is a common species in the Jurassic area in other phytocoenotic arrangements.

Fagus sylvatica as an admixture in the tree stand and *Athyrium filix-femina*, *Dryopteris filix-mas*, *Mycelis muralis*, and *Veronica officinalis* were well represented as a group of species distinguishing the *Vaccinio-Abietenion* suballiance. *Hieracium murorum* and *Solidago virgaurea s.s* (cf. Matuszkiewicz J. 1977), among others, rarely occurred.

Zaręba (1971) stressed the attachment of the phytocoenoses discussed here into the *Piceion excelsae* alliance. This is determined by constant characteristic species such as *Picea abies* (present in all forest layers) and *Plagiothecium curvifolium*, as well as by distinguishing species (*Rubus idaeus* and *Senecio ovatus*). It is worth paying attention to the presence (sporadic) of other "true" characteristic species of the alliance mentioned above, such as *Calamagrostis villosa*, *Lycopodium annotinum* and *Moneses uniflora*. In this context (see Matuszkiewicz J. 1977) as the representation of the *Dicrano-Pinion* alliance seemed very weak (*vide* "*Pino-Quercetum abietetosum*") and was restricted to the occurrence of the pine *Pinus sylvestris* in some tree stands. A higher share of pines and only a sporadic presence of *Chimaphila umbellata*, *Juniperus communis s.s.*, and *Leucobryum glaucum* in patches of fir forests is an evident effect of the forest management (see Kurowski 1979, 1993; Brzeg, Rutkowski 2004; Marciniuk, Wierzba 2004; Orzechowski 2007).

The *Piceetalia excelsae* order (=*Vaccinio-Piceetalia*) and the *Vaccinio-Piceetea* class were represented in the tree stand by the aforementioned *Pinus sylvestris* (singly and in a varied admixture of this species) in the phytocoenoses of the upland fir coniferous forest should be acknowledged as a natural feature of phytocoenoses (see, among others, tables by: Dziubałtowski 1928; Matuszkiewicz J. 1977; Jost-Jakubowska 1979; Krzemińska-Freda 1979; Głazek, Wolak 1991 or Izdebski et al. 1992). *Trientalis europaea*, *Vaccinium myrtillus*, and *Pleurozium schreberi* were constant or frequent elements of the herb or moss layers, except for the pine. Among rarer species, the presence of *Pyrola minor*, *Vaccinium vitis-idaea*, *Hylocomium splendens*, and *Ptilium crista-castrensis*, should be emphasized.

Mild mesotrophic character of the association being discussed is strengthened by the appearance of over 30 deciduous forest species that are characteristic for the *Querco-Fagetea* class, which occurred in the majority with a lower degree of constancy. *Corylus avellana*, *Milium effusum*, and *Viola riviniana* could be noted as distinguishing for the association and the suballiance as additional species to the said ones. Other species were more often found in patches of a more fertile subassociation.

Accompanying species, such as *Carex pilulifera*, *Dryopteris carthusiana*, *Maianthemum bifolium*, *Moehringia trinervia*, *Luzula pilosa*, *Oxalis acetosella*, *Pteridium aquilinum*, *Dicranella heteromalla*, *Hypnum cupressiforme*, *Plagiomnium affine*, and *Polytrichastrum formosum*, which are transitive from the phytocoenoses of acid beech woods and oak forests, prevailed. These were plants that constantly and abundantly grew in many phytocoenoses that had medium acidophilous all-forest features. It should be noted that the constant combination of the above species was present in the entire range of the *Abietetum albae* association, practically in the entire country (see Table 5).

Phytocoenoses of the upper fir coniferous forest aggregated a set of valuable elements of native regional Jurassic flora. Eighteen species of vascular plants and mosses are under the protection of the law (Regulation of the Minister of the Environment — Dz.U. 2014). The orchid *Malaxis monophyllos* is under strict protection, while *Blechnum spicant*, *Chimaphila umbellata*, *Epipactis helleborine*, *Lycopodium annotinum*, *Moneses uniflora*, *Pyrola minor*, as well as *Climacium dendroides*, *Dicranum scoparium*, *Eurhynchium angustirete*, *Hylocomium splendens*, *Leucobryum glaucum*, *Pleurozium schreberi*, *Polytrichum commune*, *Pseudoscleropodium purum*, *Ptilium crista-castrensis*, *Sphagnum girgensohnii*, and *Thuidium tamariscinum* are in the group of partly protected species.

Among the rare and threatened plant taxa in the central part of the Cracow-Częstochowa Upland, special attention should be paid to: **endangered species (EN)** — *Chamaecytisus ruthenicus* and *Ptilium crista-castrensis*, **vulnerable species (VU)** — *Circaea alpina*, *Malaxis monophyllos* and *Rubus pedemontanus*, **nearly threatened species (NT)** — *Chimaphila umbellata*, *Hepatica nobilis*, *Leu-*

cobryum glaucum, *Moneses uniflora* and *Rubus nessensis*, as well as to the **lowest care species (LC)** — *Actaea spicata*, *Amblystegium serpens*, *Atrichum undulatum*, *Brachytheciastrum velutinum*, *Brachythecium rutabulum*, *Carex pilulifera*, *Climacium dendroides*, *Dentaria bulbifera*, *Dicranella heteromalla*, *Dicranum scoparium*, *Eurhynchium angustirete*, *Herzogiella seligeri*, *Hylocomium splendens*, *Hypnum cupressiforme*, *Kindbergia praelonga*, *Lophocolea heterophylla*, *Lycopodium annotinum*, *Mnium hornum*, *Orthilia secunda*, *Orthodicranum montanum*, *Oxyrrhynchium hians*, *Plagiomnium affine*, *P. undulatum*, *Plagiothecium curvifolium*, *P. denticulatum*, *P. laetum*, *Pleurozium schreberi*, *Pohlia nutans* ssp. *nutans*, *Polygonatum verticillatum*, *Polypodium vulgare*, *Polytrichiastrum formosum*, *Polytrichum commune*, *Pseudoscleropodium purum*, *Sciuro-hypnum oedipodium*, and *Thuidium tamariscinum* (Parusel, Urbisz [eds.] 2012; Stebel et al. 2012). Some of these species are protected as it was stated earlier in this chapter. It is worth stressing that *Malaxis monophyllos* has the status of a vulnerable species in Poland.

The phytogeographic group that is comprised of widely understood mountain elements seems to be very interesting according to Zając (1996). It includes eight taxa: *Abies alba*, *Calamagrostis villosa*, *Cardaminopsis halleri*, *Malaxis monophyllos*, *Polygonatum verticillatum*, *Rubus hirtus*, *Sambucus racemosa*, and *Senecio ovatus*.

Local-habitat differentiation. A preliminary numerical analysis (see the dendrogram of the similarity of the patches, Fig. 4) and then a traditional analysis and verification of the total phytosociological material allowed for the final division into two subassociations (*Abietetum albae typicum* and *A.a. circaeetosum alpinae*) within the one association, *Abietetum albae*, in the central part of the Jurassic area. That division was based on the presence or absence of representatives of the distinguishing group of species, which differed from the more fertile part of the association. Although the problem was treated differently by various authors, in general, it is in agreement with the concept of Matuszkiewicz J. (1977).

***Abietetum albae typicum* J. Mat. 1977** (*non A.a. typicum sensu* Dziubałtowski 1928 *nom. inval.*, Art. 3 d, e ICPN)

Nomenclatoric type: *Abietetum polonicum typicum*, rel. 29 in Table 8 (Matuszkiewicz J. 1977), *lectotypus hoc loco*

The regional shape of the typical subassociation (Table 3) was distinguished from the more fertile subassociation for the most part in a negative manner. It included floristically poorer patches. The mean number of taxa per one relevé amounted to 38 and varied between 29 and (exceptionally) 51. First of all, there was the lack of an entire set of eutrophic and medium hygrophilous species in these phytocoenoses, which differed from *A.a. circaeetosum alpinae*. On the other hand, coniferous forest species like *Pleurozium schreberi* and *Trientalis europaea* grew significantly more frequently and more abundantly in the typical subasso-

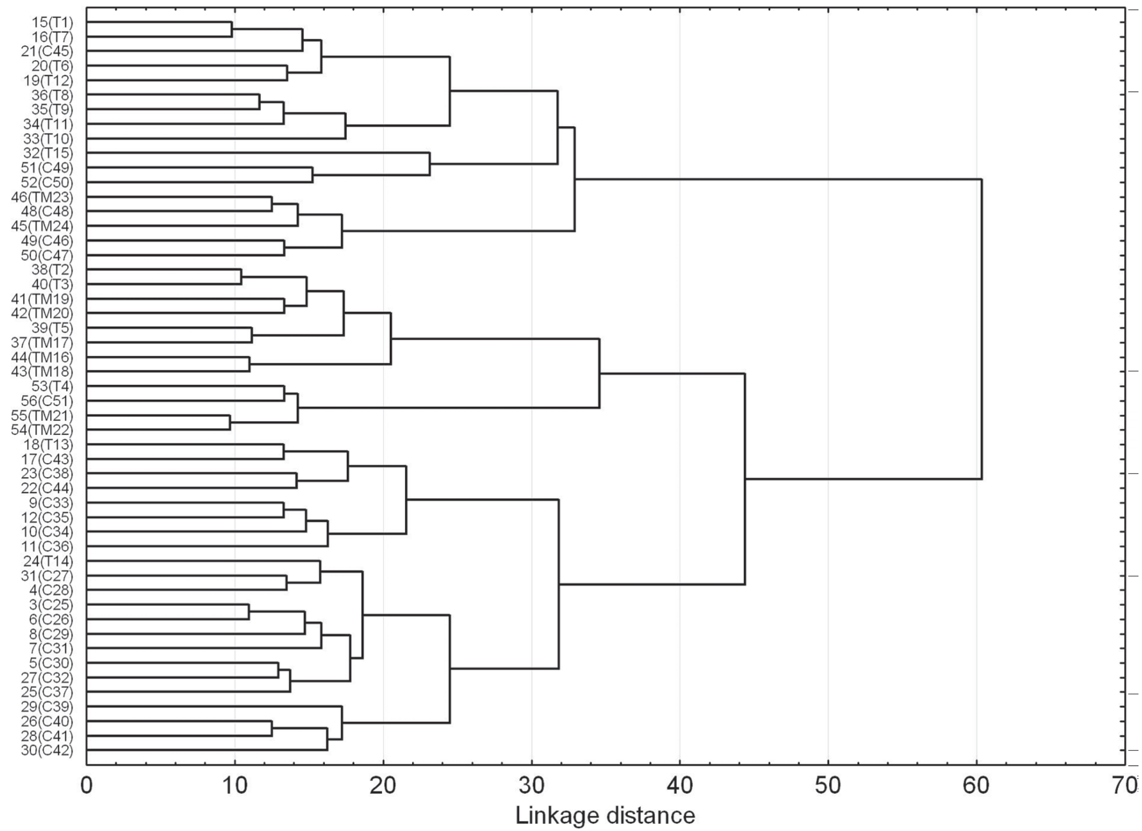

Fig. 4. Similarity of entire floristical combination of patches of the *Abietetum albae* analysed on the area of central part of the Cracow-Częstochowa Upland

Explanations: numbers before brackets are the numbers of relevés in the field (see Fig. 2), numbers in brackets are successive numbers of relevés in table *A. a. typicum* (T), *A. a. typicum* the *Millium effusum* variant (TM) and *A. a. circaeetosum alpinae* (C)

Table 3. *Abietetum albae typicum* J. Matuszkiewicz 1977

Successive no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Constancy 1—15	16	17	18	19	20	21	22	23	24	Constancy 16—24	Constancy 1—24
Field no. of relevé	15	38	40	53	39	20	16	36	35	33	34	19	18	24	32		44	37	43	41	42	55	54	46	45		
Date day	18	20	20	10	20	18	18	20	20	20	20	18	18	19	20		20	20	20	20	20	10	10	21	21		
Date month	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08		08	08	08	08	08	08	08	08	08		
Date year	09	09	09	11	09	09	09	09	09	09	09	09	09	09	09		09	09	09	09	09	11	11	09	09		
Altitude [m a.s.l.]	390	418	417	285	414	375	390	380	380	375	375	375	395	455	351		406	415	405	402	403	287	283	425	427		
Slope exposure	—	NE	E	—	W	W	SW	N	—	—	—	S	—	NE	—		NE	NE	NNE	S	SW	—	—	—	S		
Inclination [°]	—	5	12	—	10	5	3	2	—	—	—	5	—	3	—		8	15	10	5	7	—	—	—	12		
Density of tree layer a1 [%]	75	85	80	40	40	65	80	60	60	70	75	40	80	50	75		80	70	65	70	80	70	45	80	65		
Density of tree layer a2 [%]	10	10	15	60	60	25	10	50	30	30	15	50	15	35	20		10	30	25	25	10	20	60	30	30		
Density of shrub layer b [%]	5	5	+	10	20	15	5	25	10	15	10	5	+	20	5		10	5	20	15	15	10	10	10	10		
Cover of herb layer c [%]	20	55	70	50	30	35	25	60	40	50	60	15	15	60	25		75	40	60	30	75	40	40	25	50		
Cover of moss layer d [%]	5	15	5	+	10	35	10	15	+	10	5	5	5	25	75		35	15	40	15	10	25	20	+	10		
Maximum height of trees a1 [m]	29	29	32	—	—	31	29	33	—	—	32	30	31	25	28		36	—	—	32	30	—	32	30	—		
Maximum diameter of *Abies* [cm]	55	46	45	46	—	49	45	44	—	—	36	60	58	35	24		90	—	—	60	55	70	38	32	—		
Maximum diameter of *Picea* [cm]	42	25	32	—	—	52	46	31	—	—	37	—	—	26	28		—	—	—	—	—	—	—	30	—		
Maximum diameter of *Pinus* [cm]	—	—	30	55	—	—	—	—	—	—	—	—	—	—	25		—	—	—	—	48	—	46	32	—		
Maximum diameter of *Betula* [cm]	—	—	—	—	—	—	—	46	—	—	48	—	—	—	—		—	—	—	—	40	—	—	—	—		
Maximum diameter of *Quercus* [cm]	—	24	20	65	—	—	—	—	—	—	18	—	—	—	—		—	—	—	—	—	—	—	45	—		
Maximum diameter of *Fagus* [cm]	—	22	—	—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—		
Maximum diameter of *Populus* [cm]	—	—	—	—	—	—	25	46	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—		
Area of relevé [m²]	250	400	300	200	400	400	300	300	300	400	300	400	300	300	300		400	400	300	300	400	300	250	200	300		
Number of taxa	33	36	37	30	31	38	36	40	34	35	38	30	36	42	43		47	38	51	43	42	47	48	29	37		
I. Ch., *D. *Abietetum albae*																											
Abies alba a1	4.4	5.4	4.4	2.1	2.2	3.1	3.4	2.1	2.1	1.1	2.1	2.2	4.4	3.1	1.1	V	5.4	4.4	4.4	4.4	4.4	4.4	3.4	2.1	(+)	V	V
Abies alba a2	2.2	1.1	2.1	4.4	4.4	2.1	1.1	3.2	1.1	1.1	2.1	1.1	2.1	3.1	+		1.1	3.1	3.3	2.2	2.1	2.1	4.4	2.1	2.1		
Abies alba b	+	1.2	+	2.1	2.1	+.2	.	2.2	1.1	1.1	2.2	.	.	1.2	.	V	+	1.1	.	+.2	+	1.1	1.1	2.2	+	V	V
Abies alba c	1.1	2.1	2.1	1.1	2.1	1.1	1.1	2.1	1.1	1.1	1.1	1.1	1.2	2.1	+		2.1	2.1	2.1	2.1	2.1	1.1	1.1	+	r		
**Sambucus racemosa* b	.	+	+	.	.	+	.	+.2	+	+	+	.	+.2	.	.	V	.	+	+.2	+	.	.	.	+.2	1.1	IV	V
**Sambucus racemosa* c	+	+	1.1	r	+	+	+	+	+	+	+	r	+	.	.		.	+	+	+	.	+	+	+	+		
Dryopteris dilatata (reg.)	1.2	1.2	+.2	1.2	+.2	+.2	2.2	+.2	1.2	+.2	+.2	+.2	+.2	+.2	.	V	2.2	1.2	2.2	1.2	1.2	1.2	2.2	1.2	+.2	V	V
**Rubus pedemontanus*	1.2	2.2	2.1	2.1	1.1	1.2	1.1	2.3	1.1	2.2	2.1	+	+	1.1	.	V	2.1	1.2	1.1	1.2	2.1	1.1	1.2	2.2	1.1	V	V
**Atrichum undulatum*	+.2	+.2	+.2	.	.	.	+.2	+	+.2	+.2	+.2	.	+.2	+.2	.	IV	+.2	1.2	+.2	1.2	1.2	+.2	+.2	.	+.2	V	IV
**Rubus hirtus*	+.2	1.2	1.1	.	.	1.1	+	1.2	1.1	1.2	2.3	.	.	1.2	.	IV	1.2	.	+	.	1.1	.	+.2	+.2	3.4	IV	IV
Thuidium tamariscinum	.	.	.	.	.	+.2	.	.	.	.	+.2	.	.	+.2	2.2	II	+.2	.	.	.	+.2	+.2	.	.	+.2	III	II
**Cruciata glabra*	.	.	+.2	.	.	.	.	.	.	.	.	.	+.2	.	.	I	.	.	+.2	.	.	.	+.2	.	.	II	I
II. D. var. with *Milium effusum*																											
Milium effusum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	—	+	.	+.2	1.2	+.2	+.2	.	+	+.2	IV	II
Dryopteris filix-mas (D. Suball.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	—	.	+.2	.	.	.	+.2	+.2	+.2	+.2	III	II
Poa nemoralis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	—	+.2	.	+.2	+.2	+	.	.	.	.	III	I
Moehringia trinervia	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+.2	.	+.2	II	I
Deschampsia caespitosa	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	+	.	.	.	+.2	.	+°	.	.	+.2	II	I
III. D. *Vaccinio-Abietenion*																											
Fagus sylvatica a1	+	1.1	.	1.1	.	1.1	1.1	.	.	.	.	.	2.1	.	.	IV	.	.	.	.	.	.	1.2	.	.	III	IV
Fagus sylvatica a2	+	+	1.2	.	.	2.1	1.2	+	2.1	.	+	2.2	1.1	.	+		.	.	.	.	.	1.1	1.1	2.1	1.1		
Fagus sylvatica b	.	.	.	+	.	2.2	1.2	.	1.2	+	.	1.1	+	+	+	V	.	+	.	.	+	+	+	.	+.2	V	V
Fagus sylvatica c	+	+°	r	r	.	+	+	.	.	.	+	+	+	r	+		+	+	r	+	+	+	+	+	r		
Athyrium filix-femina	1.2	2.2	3.4	.	1.2	+.2	+.2	+.2	+.2	+.2	1.2	+.2	1.2	1.2	.	V	1.2	2.3	1.2	2.2	2.2	1.2	1.2	+.2	2.2	V	V
Mycelis muralis	+	.	+	.	.	.	+	.	+	.	+	.	+	.	.	II	.	.	+	+	.	+	+.2	.	.	III	III
Solidago virgaurea s.s.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	I	.	.	.	.	.	.	.	.	.	—	I
Veronica officinalis	.	.	+	.	.	.	.	.	.	.	.	.	+.2	.	.	I	.	.	.	.	.	+	.	.	.	I	I
IV. Ch., *D. *Piceion excelsae*																											
Picea abies a1	2.1	1.1	1.1	.	.	3.1	2.1	2.1	3.3	3.4	3.4	3.1	+	2.1	3.1	V	+	1.1	.	.	1.1	.	.	3.1	4.5	IV	V
Picea abies a2	1.1	1.1	1.1	.	.	1.1	2.1	2.1	2.1	2.1	2.1	2.2	.	1.1	2.2		+	.	.	1.1	1.1	.	+	1.1	3.1		
Picea abies b	.	+°	.	.	.	+	+°	+	.	+	+°	.	.	+	1.2	V	.	.	+	+	+.2	+°	.	+	2.1	V	V
Picea abies c	+	+	+	.	r	1.1	+	+	+	2.1	+	+	+	+	2.1		1.1	.	+	.	+	+	+	+	+		
Plagiothecium curvifolium	+.2	1.2	+.2	+.2	+.2	1.2	+.2	+.2	.	1.2	+.2	+.2	+.2	1.2	+.2	V	2.2	1.2	2.2	1.2	+.2	2.2	2.2	+.2	+.2	V	V
**Rubus idaeus*	+.2	1.1	2.1	.	1.1	+.2	.	1.2	1.1	+	+.2	.	+.2	+.2	.	IV	1.2	1.1	1.1	1.1	1.1	+	+	+	2.1	V	V
**Senecio ovatus*	.	+	.	.	+	.	.	1.1	+	+	1.1	.	.	1.1	.	III	+	+	+	+	+.2	.	.	.	+	IV	III
V. Ch. *Vaccinio-Piceetea*																											
Pinus sylvestris a1	.	.	+	3.1	.	.	.	1.1	2.1	1.1	.	1.1	.	.	2.1	III	.	.	.	.	1.1	2.1	2.1	1.1	.	III	III
Pinus sylvestris b/c	.	.	.	.	.	.	.	./r	.	./r	.	.	./r	.	./+	II	./+	.	./+	.	.	./r	./+	.	.	III	II
Vaccinium myrtillus	1.2	1.2	+.2	2.3	2.1	2.3	1.2	3.3	2.3	1.3	2.3	1.1	1.2	3.4	1.2	V	1.2	1.1	1.1	1.1	1.2	1.1	2.2	+.2	1.1	V	V
Trientalis europaea	.	1.1	1.1	1.1	1.1	1.1	.	+	+	1.1	+	+	.	+.2	.	IV	2.1	+	1.1	+	1.1	1.1	1.1	+.2	1.1	V	V
Pleurozium schreberi	+.2	1.2	.	+.2	.	2.3	+.2	.	.	.	.	+.2	.	+.2	2.2	III	1.2	+.2	+.3	1.2	.	+.2	1.2	+.2	.	IV	IV
Vaccinium vitis-idaea	.	.	.	.	.	+.2	.	.	.	.	.	+	.	+	+	II	.	.	.	.	.	.	.	.	.	—	I
Pyrola minor	.	.	.	.	.	.	.	.	+.2	.	.	.	.	+.2	+.2	I	+.2	.	.	.	.	.	.	.	.	I	I
Hylocomium splendens	.	.	.	.	.	+.2	.	1.2	.	.	.	.	.	.	+.2	I	.	.	.	.	.	.	.	.	.	—	I
Ptilium crista-castrensis	.	.	.	.	.	.	+.2	.	.	+.2	.	.	.	.	+.2	I	.	.	.	.	.	.	.	.	.	—	I
Pseudoscleropodium purum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	+	.	.	.	.	.	+.2	+.2	.	.	II	I
VI. Ch. *Querco-Fagetea*																											
Acer pseudoplatanus a1	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	I	.	.	.	.	.	.	.	.	.	—	+
Acer pseudoplatanus a2	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+		.	.	.	.	.	.	.	.	.	—	
Acer pseudoplatanus b/c	.	.	.	.	.	.	.	.	.	.	.	.	.	+/+	+/+	I	.	.	.	./+	.	.	.	.	.	I	I
Corylus avellana b	.	.	.	.	.	+.2	+.2	+.2	1.2	2.1	+.2	+	.	2.2	1.1	IV	1.2	.	1.2	+.2	2.2	.	.	.	.	III	IV
Corylus avellana c	r	.	r	.	.	+	.	+	+	+	+	+	.	+	+		+	+	.	+	+	.	.	.	.		
Cerasus avium a2	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	—	r
Cerasus avium b/c	.	./r°	.	.	.	.	.	.	.	./+	.	.	.	.	.	I	.	./r	.	.	.	.	.	./+	./r	II	II
Carpinus betulus a2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	—	.	.	.	.	.	.	+	.	.	I	r
Carpinus betulus b/c	.	.	.	+/+	.	.	.	.	.	.	.	.	.	./+	.	I	.	.	.	.	.	+/+	+/+	.	.	II	I
Fraxinus excelsior b/c	./+	.	.	.	.	.	./r	.	.	.	.	./r	./+°	.	.	II	.	.	.	.	.	.	.	.	.	—	I
Acer platanoides c	.	.	.	.	.	r	r	.	.	.	.	.	.	r	.	I	.	.	.	.	.	.	.	.	.	—	I
Viola riviniana	.	.	.	+.2	.	.	r	.	.	+	+	.	.	.	.	II	.	+.2	.	.	.	+.2	r	.	.	II	II
VII. Others																											
Quercus robur a1	.	1.2	1.1	.	3.3	.	.	.	.	.	1.1	.	+	1.1	.	IV	.	2.1	.	1.1	1.1	.	.	2.1	1.1	III	IV
Quercus robur a2	.	.	+°	.	.	.	+	+	.	1.1	+	1.1	.	.	+		.	.	.	.	.	.	.	.	.		
Quercus robur b/c	./r	./+	./+	.	./r	./+	./r	+/+	./+	.	./+	.	./r	./+	./+	IV	./r	.	./+	./+	+/+	.	.	./+	+/+	IV	IV
Betula pendula a1	.	.	.	.	.	.	.	2.1	2.1	2.2	2.2	1.1	.	.	.	II	.	.	.	.	1.1	.	.	.	.	I	II
Betula pendula b	.	.	.	.	.	.	.	.	.	.	.	+	.	+.2	.	II	1.2	+	1.1	.	.	.	.	.	.	II	II
Betula pendula c	r	.	.	.	.	.	.	.	.	+	.	.	+	+	.		+	.	1.1	.	.	.	.	.	.		
Populus tremula a1	1.1	.	.	.	.	.	2.2	1.1	1.1	.	.	.	.	.	.	II	.	.	.	.	.	.	.	.	.	—	I
Populus tremula b	1.1	.	.	.	.	+	1.2	.	+	.	+°	.	.	.	.	IV	.	.	.	+	.	.	.	.	.	II	III
Populus tremula c	1.1	.	+°	.	.	+	1.1	+	+	.	+	+	r	.	+		.	.	+	+	.	.	.	.	.		
Sorbus aucuparia a2	.	.	.	+	.	.	.	+	.	.	+	.	.	2.1	.	II	2.1	.	.	.	+	.	.	.	+	II	II
Sorbus aucuparia b	.	+	.	1.1	+	1.2	.	2.2	+	1.1	+	+	.	1.2	+	V	1.2	.	2.2	2.1	1.2	2.1	2.1	.	+	V	V
Sorbus aucuparia c	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	1.1	.	+	1.1	+	.	+		
Salix caprea a2	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	—	r
Salix caprea b/c	./r	.	.	.	.	+/.	.	.	.	.	.	.	.	.	.	I	./r	.	./r	.	.	.	.	.	.	II	I
Frangula alnus b	.	+	+	.	+	+	.	1.2	+	+	.	.	.	+	.	III	1.1	+	.	+	+	.	.	.	+	IV	IV
Frangula alnus c	.	+	r	.	+	+	.	+	.	+	.	.	.	r	+		+	.	+	+	+	+	.	.	.		
Maianthemum bifolium	2.1	2.1	1.2	3.1	2.1	2.1	2.1	2.1	1.1	1.1	2.1	2.1	1.2	1.2	.	V	2.1	2.1	2.1	2.1	3.1	2.1	2.1	+.2	+	V	V
Luzula pilosa	1.2	+.2	+.2	1.2	+.2	1.2	2.2	1.2	+.2	+.2	1.2	1.2	1.2	1.2	2.2	V	1.2	.	1.2	+.2	2.2	1.2	1.2	+.2	+.2	V	V
Dryopteris carthusiana	1.2	1.2	1.2	+.2	+.2	+.2	1.2	+.2	+.2	+.2	1.2	+.2	+.2	+.2	.	V	+.2	+.2	+.2	+.2	1.2	+.2	1.2	+.2	+.2	V	V
Dicranella heteromalla	+.2	+.2	+.2	+.2	1.2	+.2	2.2	+.2	+.2	+.2	+.2	+.2	1.2	1.2	.	V	2.2	1.2	1.2	+.2	1.2	.	+.2	+.2	+.2	V	V
Oxalis acetosella	2.2	2.2	2.3	2.2	1.3	1.2	1.2	2.3	.	1.3	2.2	1.2	+.2	+.2	.	V	1.2	1.1	.	1.3	1.2	2.3	2.2	2.2	1.2	V	V
Polytrichastrum formosum	+.2	2.2	1.2	.	2.2	2.2	+.2	1.2	+.2	+.2	1.2	1.2	1.2	2.3	.	V	2.2	2.3	2.3	2.3	1.2	1.2	1.2	.	1.2	V	V
Sciuro-hypnum oedipodium	+.2	+.2	+.2	.	1.2	2.2	.	1.2	1.2	1.2	+.2	+.2	.	1.2	2.2	IV	+.2	1.2	+.2	+.2	+.2	+.2	+.2	+.2	1.2	V	V
Pohlia nutans	+.2	+.2	+.2	+.2	+.2	+.2	+.2	.	+.2	.	+.2	+.2	+.2	+.2	.	IV	+.2	+.2	+.2	+.2	+.2	+.2	+.2	.	+.2	V	V
Plagiomnium affine	.	+.2	.	+.2	+.2	2.2	.	+.2	.	1.2	+.2	+.2	.	1.2	3.4	IV	1.2	2.2	+.2	1.2	2.2	2.3	2.2	.	1.2	V	IV
Deschampsia flexuosa	1.2	1.2	+.2	1.3	1.2	2.2	+.2	+.2	1.2	.	1.2	+.2	+.2	.	+.2	V	.	+.2	+.2	.	+.2	+.2	+.2	.	.	III	IV
Calamagrostis epigejos	.	.	.	+	+.2	+.2	.	+°	+.2	.	.	+	+.2	.	.	III	+.2	+.2	1.2	+.2	.	.	+°	.	.	III	III
Carex pilulifera	.	1.2	+.2	.	.	.	.	+.2	+.2	+.2	+.2	.	.	+.2	.	III	1.2	+.2	+.2	+.2	+.2	.	.	.	+.2	IV	III
Galeopsis pubescens	.	r	.	.	r	.	+	.	+	.	.	.	.	.	.	II	.	.	+	+	r	.	+	+	+	IV	III
Lophocolea heterophylla	.	.	+.2	.	.	+.2	+.2	.	.	+.2	.	.	.	+.2	.	II	+.2	.	+.2	+.2	.	+.2	+	.	.	III	III
Plagiothecium laetum	.	+.2	+	.	.	.	.	.	.	.	+.2	.	.	+.2	.	II	+	.	+.2	.	+	.	.	+	+.2	III	II
Carex ovalis	.	+°	.	.	+.2	.	.	+.2	+.2	.	+.2	.	.	.	.	II	1.2	+.2	1.2	.	+.2	.	.	.	.	III	II
Hypnum cupressiforme	+.2	.	+	+.2	+.2	.	.	+.2	.	.	+.2	.	+.2	+.2	.	III	.	.	.	.	.	.	.	+.2	.	I	II
Agrostis capillaris	.	.	+	.	.	.	+.2	.	.	.	.	.	+.2	.	.	I	+.2	.	+.2	.	+.2	.	.	.	.	II	II
Plagiothecium denticulatum	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	+	I	+.2	+.2	.	.	.	.	+.2	.	.	II	II
Brachytheciastrum velutinum	.	.	.	.	.	.	.	+.2	+.2	1.2	.	.	.	+.2	.	II	.	.	.	+.2	.	.	.	.	.	I	II
Impatiens parviflora	.	+°	r	.	+	.	.	.	.	.	.	.	.	.	.	I	.	+	.	.	.	.	.	+.2	1.1	II	II
Pteridium aquilinum	.	.	.	+	.	.	.	.	.	2.1	2.3	.	.	.	.	I	.	.	.	.	.	+	+	1.2	1.3	III	II
Herzogiella seligeri	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	+.2	.	.	+.2	+.2	.	.	.	II	I

Sporadic species: III. *Fragaria vesca* 15, 18(+); *Galeobdolon luteum* 7(r); *Hieracium murorum* 7, 15(+); **IV.** *Calamagrostis villosa* 18(1.2); *Lycopodium annotinum* 8, 22(+); *Moneses uniflora* 6(+), 15(2.2); **Polygonatum verticillatum* 19, 20(+); **V.** *Betula pubescens* b 14(+); *Chimaphila umbellata* 15(+); *Dicranum scoparium fo.* 5, 16(+); *Juniperus communis s.s.* b 15(+); *Leucobryum glaucum* 19(+); *Malaxis monophyllos* 15(+); *Orthilia secunda* 15(+); **VI.** *Anemone nemorosa* 21, 22(+); *Brachypodium sylvaticum* 19(r); *Carex digitata* 22(+); *C. remota* 22(+); *Equisetum sylvaticum* 14(+); *Euonymus verrucosa* b/c 1, 4, 15(+); *Festuca gigantea* 21, 22(+); *Melica nutans* 21(+); *Scrophularia nodosa* 22(+); **VII.** *Brachythecium rutabulum* 8, 21(+); *Calamagrostis arundinacea* 4, 21, 22(+); *Calluna vulgaris* 16, 18(+); *Cardaminopsis halleri* 13(+); *Carex pallescens* 9, 20(+); *Chamaecytisus ruthenicus* 15(+); *Chamaenerion angustifolium* 16, 18(r); *Climacium dendroides* 15(+); *Convallaria majalis* 22(+); *Crataegus rhipidophylla* b 21(+); *Dicranum montanum* 22(+); *Epilobium montanum* 19(r); *Geranium robertianum* 15(r); *Hieracium lachenalii* 15(+); *H. pilosella* 15, 16(+); *Hypericum maculatum* 8(r), 18(+); *H. perforatum* 13(+); *Juncus effusus* 16, 18(+); *Kindbergia praelonga* 8(+), 15(1.2); *Leontodon hispidus s.s.* 15(+); *Luzula multiflora* 13, 18(+); *Mnium hornum* 7(+); *Padus serotina* c 1, 7(r), 4(+); *Quercus petraea* a1 4(1.1), a2 4(1.2), c 4, 15, 21, 22(+); *Ranunculus repens* 18, 20(+); *Rubus plicatus* 2, 6, 11(+); *Rubus ×corylifolius* 21(+); *Rumex acetosella* 13(+); *Thymus serpyllum* 15(+); *Urtica dioica* 4, 20(r); *Viburnum opulus* c 22(r).

ciation. *Ptilium crista-castrensis* and *Vaccinium vitis-idaea* occurred almost exclusively in its patches, which is in agreement with the data collected by Brzeg and Rutkowski (2004). Analyses of the soil profiles (see Table 2), which illustrated a stronger acidification of at least higher horizons of the profile occurring in that type of phytocoenoses, indicated (to a certain degree) poorer character of the sites that were covered by phytocoenoses of the *A.a. typicum* subassociation.

Within the subassociation two local variants were distinguished, which still have not been described in the literature on the subject — that is, a typical variant and variant that is somewhat more fertile with *Milium effusum*, and which

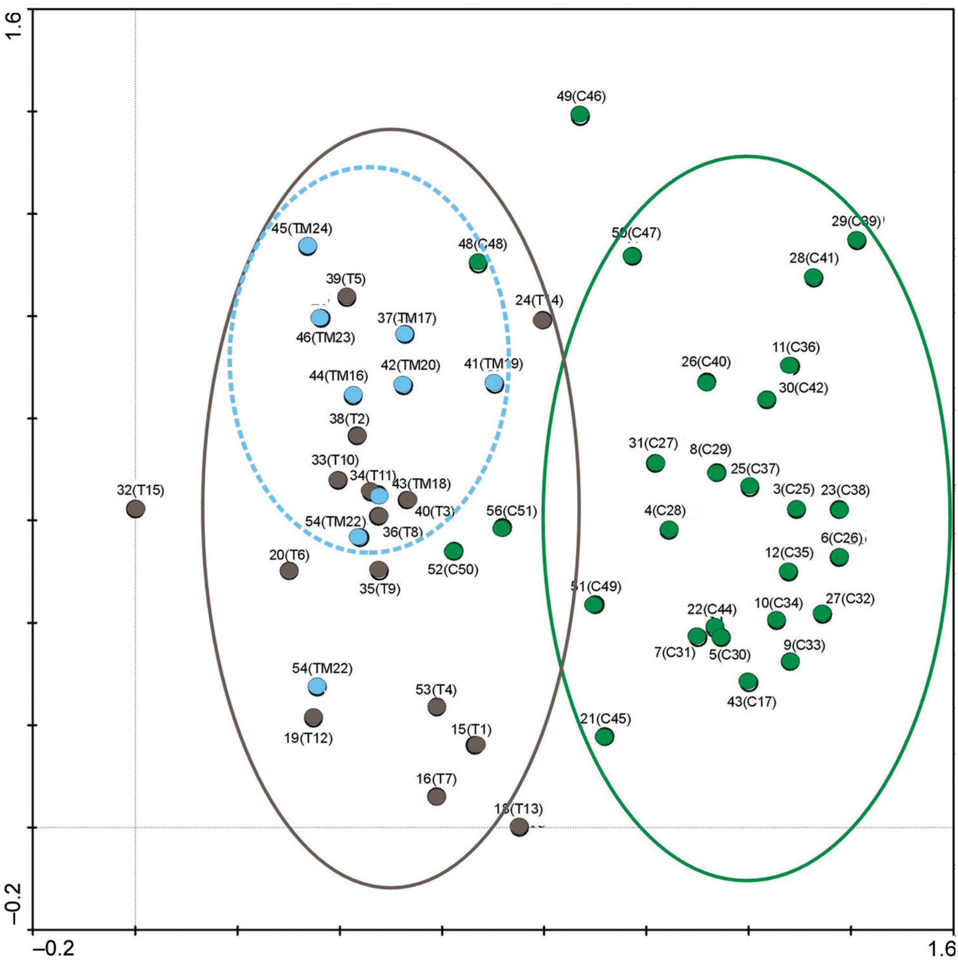

Fig. 5. Differentiation of all patches of the *Abietetum albae* (DCA) on the area of central part of the Cracow-Częstochowa Upland

Explanations: numbers before brackets are the numbers of relevés in the field (see Fig. 2), numbers in brackets are successive numbers of relevés in table *A. a. typicum* (T), *A. a. typicum* the *Millium effusum* variant (TM) and *A. a. circaeetosum alpinae* (C) is transitive to the next subassociation. This division was also confirmed by numerical analyses, which resulted in a dendrogram of the similarity of patches (Fig. 4) and the arrangement of particular relevés in a similarity diagram after DCA analysis (Fig. 5).

The typical variant (Table 3 rel. 1—15) had no differing species of its own, and thus it represents a medium shape of the subassociation, which occurs more frequently in the area that was studied. The number of species that were present in the relevés that documented this syntaxon of lower rank varies within a range of 30—43, and is reaching a mean value of 36.

The *Milium effusum* variant (rel. 16—24 in Table 3) had a group of five differential species (*Deschampsia caespitosa*, *Dryopteris filix-mas*, *Milium effusum*, *Moehringia trinervia*, and *Poa nemoralis*), which appeared in a typical variant sporadically rather than numerously. A little higher mean number of species in the relevés, amounting in 42 (29—51), was evidence for the somewhat higher floristic richness of the patches of the variant being discussed.

Typical subassociations in the diagnosis presented in general developed in an upland mixed coniferous forest type of habitat (BMwyż type site) used in forest management.

Locations of the relevés from Table 3 (*Abietetum albae typicum*):

1(15), 7(16), 13(18): the Pazurek nature reserve, the southern edges of the Cisowa Rock;

2(38), 3(40), 5(39), 17(37): the village of Trzyciąż, the Dłubniański Landscape Park, 421 forest sections to the south of the Trzyciąż—Zagórowa road;

4(53) [N 50.71318° E 019.49390° ± 10 m], 21(55) [N 50.71397° E 019.49518° ± 12 m], 22(54) [N 50.71318° E 019.49453° ± 9 m]: Apolonka, the Kaliszak nature reserve, southern part;

6(20), 12(19): to the NW of the village of Podlesice, the Pazurek Forestry, 116 forest section;

8(36), 9(35): to the NW of the village of Zabagnie, the Poręba Forestry, 157 forest section;

10(33), 11(34): to the NW of the village of Zabagnie, the Poręba Forestry, 156 forest section;

14(24): the village of Strzegowa Poduchowne, the Wodąca River Valley, forests that are under private agricultural ownership to the E of Grodzisko Chłopskie Hill;

15(32): the village of Kiełkowice nad Dołami, forests that are under private agricultural ownership to the west side of the red trip to the SE of Biały Kamień Hill;

16(44), 18(43), 19(41), 20(42): the village of Trzyciąż, the Dłubniański Landscape Park, on the northern side of the Trzyciąż—Zagórowa road;

23(46), 24(45): to the north of the village of Michałówka, forests that are under private agricultural ownership to the SW of Łysica Hill.

***Abietetum albae circaeetosum alpinae* J. Mat. 1977**

Nomenclatoric type: *Abietetum polonicum circaeetosum* (*alpinae*), rel. 21, Table 8 (Matuszkiewicz J. 1977), *lectotypus hoc loco*

Abietetum albae circaeetosum alpinae (Table 4) had a much stronger mesotrophic character than the first of the upland's fir subassociations from the central part of the Jurassic area that have been discussed so far. It was distinguished in a positive way by numerous groups of eutrophic and/or medium hygrophilous species (14) from among which five reached high constancy degrees of III—IV in that unit; these were: *Galeobdolon luteum*, *Galium odoratum*, *Gymnocarpium dryopteris*, *Festuca gigantea*, and *Viola reichenbachiana*. Other species that distinguished the subassociation, which were pointed out by Matuszkiewicz J. (1977), that is, *Circaea alpina*, *Epilobium montanum*, *Geranium robertianum*, and *Phegopteris connectilis* appeared with a lower frequency. The group of diagnostic species was significantly enriched in species in comparison with the original diagnosis, which was an effect of the comparison studies. It should be stressed that the group of taxa that are transitive from the class including deciduous forests (*Querco-Fagetea*) prevail. Special attention should be paid to taxa from the *Alnion incanae* (*=Alno-Ulmion*) alliance such as: *Circaea lutetiana*, *Festuca gigantea, Eurhynchium angustirete* and *Plagiomnium undulatum.* Significant share of the deciduous forest elements of meso-eutrophic character suggested the need for a description in the case of the majority of the patches in the subassociation that was studied as those that represented an upland mixed deciduous forest habitat type (LMwyż type site).

Patches of the *A.a. circaeetosum alpinae* are noticeably richer than those representing a typical subassociation. The number of species per one relevé varies between 36 and 63, and is 48 on average.

The analysis of the samples from two soil profiles that were performed in the patches of the discussed subassociation on the slopes of the Goncerzyca Rock in the Wodąca River Valley and Rząsowy Rock near Hucisko Ryczowskie (Table 2) indicated that they had developed on deficient grey Luvisols formed of silty clays, which were distinctly less acidic than in the case of *A.a. typicum*.

In Table 4 the phytosociological relevé no. 28 (the field number of relevé 47), which was made in the area of Michałówka village on the slopes of Bald Mountain (*Łysa Góra*), has been placed after the column with the constancy degrees. It documents the exemplary floristic composition of the strongly transformed phytocoenose of the *A.a. circaeetosum alpinae* subassociation, which according to Faliński (1966) presents an advanced degeneration phase of that syntaxon. This deformation has been caused by the planting of pine in the vicinity of well-developed fir phytocoenoses and was manifested, among others, by creating a poorer diagnostic species groups, over-development of fern *Athyrium filix-femina* and brambles (*Rubus hirtus* especially), as well as the abundant appearance of *Impatiens parviflora*. According to Olaczek (1974) and Kasprowicz (1996a), the occurrence of at least three separate degeneration forms: pinetisation with pine *Pinus sylvestris*, epilobietisation (extraordinary share of open-space species usually covering clear-cuttings) and neophytisation (expansion of geographically alien species) can be observed simultaneously in this patch. The presence of similar arrangements in many locations within the entire area of the study prove that upland fir forests were much more widely distributed in the past (see Urbisz 2012 — Fig. 1), and that nowadays they are being gradually eliminated by some forms of forest management, especially by the favouritism in relation to pine stands (Brzeg, Rutkowski 2004).

Locations of relevés from Table 4 (*Abietetum albae circaeetosum alpinae*):

1(3), 4(4), 7(7): the village of Strzegowa Poduchowne, the Wodąca River Valley, forests that are under private agricultural ownership on the slopes of Grodzisko Pańskie Hill;
2(6), 5(8), 6(5): the village of Strzegowa Poduchowne, the Wodąca River Valley, forests that are under private agricultural ownership on the S slopes of Goncerzyca Rock;
3(31), 8(27), 15(29), 16(26), 17(28), 18(30): the village of Strzegowa Poduchowne, the Wodąca River Valley, forests that are under private agricultural ownership on the N slopes of Goncerzyca Rock;
9(9), 10(10), 11(12), 12(11): the village of Hucisko Ryczowskie, Rząsowy Rock, forests that are under private agricultural ownership, on the N slopes of the hill 435 m a.s.l.;
13(25): the village of Strzegowa Poduchowne, the Wodąca River Valley, forests that are under private agricultural ownership on the E slopes of Grodzisko Chłopskie Hill;
14(23), 20(22): the village of Strzegowa Poduchowne, the Wodąca River Valley, forests that are under private agricultural ownership on the E slopes of Biśnik Rock;
19(17): The Pazurek nature reserve, the southern edges of Cisowa Rock;
21(21): to the NW of the village Podlesice, the Pazurek Forestry, 116 forest section;
22(49), 23(50): to the north of the village Miechówka, the Bold Mountain Forest, the Poręba Forestry, 145 forest section;
24(48), 28(47): to the north of the village Michałówka, forests that are under private agricultural ownership to the west from the hill 454 m a.s.l.;
25(51), 26(52): to the south from Kocikowa, the Smoleń Forestry, 179 forest section;
27(56) [N 50.71410° E 019.49546° ± 9 m]: Apolonka, the Kaliszak nature reserve, the southern part.

Table 4. *Abietetum albae circaeetosum alpinae* J. Matuszkiewicz 1977

Successive no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		28
Field no. of relevé	3	6	31	4	8	5	7	27	9	10	12	11	25	23	29	26	28	30	17	22	21	49	50	48	51	52	56		47
day	17	17	19	17	17	17	17	19	18	18	18	18	19	19	19	19	19	19	18	19	18	21	21	21	21	21	10		21
Date month	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08		08
year	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	09	11		09
Altitude [m a.s.l.]	395	449	433	405	440	420	430	418	420	422	425	426	460	442	420	415	410	410	395	439	380	360	357	440	381	375	280		435
Slope exposure	SSW	S	NE	SW	SE	SW	E	W	SSW	SWW	NE	N	N	W	N	NWW	NE	NE	S	W	SWW	N	NE	SW	E	NE	SW		S
Inclination [°]	5	7	10	5	5	8	7	15	8	10	15	7	7	8	5	5	7	5	5	4	7	20	12	8	3	2	3		10
Density of tree layer a1 [%]	70	70	50	60	70	50	50	60	60	60	70	60	60	60	60	60	60	75	70	60	75	50	50	70	70	80	60		60
Density of tree layer a2 [%]	35	25	30	35	10	40	50	30	30	40	15	30	35	40	35	30	20	15	30	40	25	40	40	20	25	10	35		25
Density of shrub layer b [%]	10	15	15	15	10	15	15	15	10	10	15	15	10	15	15	15	20	20	+	5	5	15	20	30	20	10	10		5
Cover of herb layer c [%]	25	30	40	35	40	40	50	30	40	60	65	40	60	40	50	40	60	50	15	25	20	30	30	45	90	80	45		70
Cover of moss layer d [%]	5	10	10	15	15	5	5	10	5	10	15	25	20	10	40	25	50	25	+	10	10	15	10	10	60	50	20		5
Maximum height of trees a1 [m]	30	—	34	30	33	—	—	35	33	35	—	35	—	30	—	36	34	—	—	—	—	—	35	36	—	29	35		—
Maximum diameter of *Abies* [cm]	31	—	—	48	37	—	—	56	55	62	—	53	—	—	—	40	58	56	—	56	—	—	42	30	—	16	78		—
Maximum diameter of *Picea* [cm]	25	—	—	23	25	—	—	—	—	—	—	—	—	—	—	38	39	—	—	—	—	—	41	46	—	35	—		—
Maximum diameter of *Pinus* [cm]	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	45	—	—	—	—	—	35	—	41	58		—
Maximum diameter of *Quercus* [cm]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	31	40	—	—	—	1—27	—
Area of relevé [m²]	300	300	300	400	250	300	400	300	400	300	400	400	400	400	400	400	300	300	300	300	300	300	400	400	400	400	300		300
Number of taxa	36	53	45	45	46	39	39	47	44	50	50	53	48	48	49	50	56	46	37	47	40	42	53	49	63	61	55		35
I. Ch., *D. *Abietetum albae*																													
Abies alba a1	4.4	4.4	3.1	4.4	4.4	3.4	3.4	4.4	4.4	4.4	4.4	4.4	4.4	3.1	4.4	4.4	4.4	4.4	4.4	3.1	3.1	.	2.1	1.1	1.1	1.1	3.1	V	.
Abies alba a2	2.1	2.2	2.1	2.1	1.1	3.3	3.3	2.1	2.2	3.2	2.1	3.3	3.1	2.1	3.4	2.2	2.1	2.1	2.2	2.1	2.1	3.3	3.1	2.1	1.1	2.1	3.1		1.1
Abies alba b	1.1	1.1	1.1	1.1	1.1	1.1	1.1	.	2.1	2.2	2.2	2.1	2.1	1.1	+	1.1	+	2.2	+	1.2	1.2	1.1	1.2	2.1	.	.	1.2	V	+
Abies alba c	2.1	1.1	1.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.2	1.1	1.1	1.1	.	r	.	+	+	2.1		.
**Sambucus racemosa* b	.	.	.	+	+	.	.	1.1	.	+	+	+	.	.	.	.	.	.	.	.	+	+.2	+	+	1.1	+	+	IV	.
**Sambucus racemosa* c	.	.	.	.	+	.	.	.	+	1.1	+	+	.	.	.	+	.	.	r	.	+	.	1.1	+	+	+	1.1		.
Dryopteris dilatata (reg.)	1.2	+.2	1.2	+.2	+.2	+.2	+.2	+.2	+.2	.	+.2	+.2	+.2	+.2	1.2	+.2	+.2	+.2	+.2	+.2	+.2	1.2	+.2	1.2	1.2	+.2	1.2	V	+.2
**Rubus pedemontanus*	2.1	2.1	1.1	1.1	1.2	1.1	2.2	2.1	1.1	2.2	2.2	2.1	1.1	1.2	.	2.2	2.3	1.3	+	1.2	2.3	1.1	1.2	2.3	+.2	2.1	2.2	V	1.3
**Atrichum undulatum*	1.2	1.2	1.2	+.2	1.2	+	1.2	1.2	1.2	1.2	1.2	2.2	1.2	2.2	+.2	1.2	1.2	+.2	+.2	1.2	+.2	+.2	+.2	+.2	.	+.2	.	V	1.2
**Rubus hirtus*	.	+.2	.	.	.	.	.	.	.	+.2	.	.	.	.	2.1	.	1.2	1.2	.	1.2	1.2	.	1.2	1.2	+	1.2	+.2	III	3.4
Thuidium tamariscinum	.	.	.	.	+.2	.	.	.	.	.	+.2	+.2	+.2	.	.	.	.	.	.	.	.	.	+.2	.	.	1.2	1.2	II	.
Cruciata glabra	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	+	I	.
II. D. reg. *A.a. circaeetosum alpinae*																													
Galium odoratum	+	+.2	.	.	+	+	1.1	1.3	+	+	1.2	+	+	+	+	.	.	+.2	+	+.2	+	.	r	.	+.2	+	r	IV	.
Gymnocarpium dryopteris	+.2	+.2	+	1.2	.	1.3	.	+.2	.	+.2	.	.	+.2	+.2	2.1	+.2	2.3	2.3	.	+.2	1.2	2.3	1.2	.	.	.	+.2	IV	.
Viola reichenbachiana	+	+	.	+	+.2	.	.	.	+	+.2	+	.	.	+.2	.	.	.	.	+	+	+	.	r	.	+	+	.	III	+.2
Festuca gigantea	.	+	+.2	.	+	.	.	.	+.2	.	r	.	r	.	.	+	+	.	r	r	.	.	.	+	+.2	.	+	III	+.2
Galeobdolon luteum	.	.	.	.	.	.	.	1.1	.	.	1.2	+	.	1.2	+	r	+.2	.	.	+.2	+.2	+	1.2	.	.	.	.	III	.
Circaea alpina	.	.	+	.	.	.	.	.	.	.	+.2	.	.	.	r	+.2	r	+.2	.	.	.	r	.	.	.	+.2	.	II	.
Deschampsia caespitosa	.	.	.	+.2	.	.	.	.	.	.	.	.	.	+.2	+.2	+.2	.	.	.	+.2	.	+.2	.	+.2	.	.	.	II	+.2
Geranium robertianum	.	.	+	.	.	.	.	.	.	r	.	.	.	.	+	.	.	r	.	.	.	+	.	.	+	r	.	II	+
Paris quadrifolia	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	+	.	.	.	+.2	+.2	.	.	.	II	.
Circaea lutetiana	.	.	.	.	.	.	+	.	.	+	.	+.2	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	II	+.2
Phegopteris connectilis	.	.	.	.	.	.	.	1.3	.	.	.	.	.	.	+.3	.	+.2	.	.	.	.	1.3	+.2	+.2	.	.	.	II	.
Plagiomnium undulatum	.	.	.	.	.	.	.	.	.	.	+.2	2.2	.	+.2	1.2	.	+.2	.	.	+.2	.	.	.	.	.	.	.	II	.
Eurhynchium angustirete	.	.	+.2	.	.	.	.	.	.	.	+.2	+.2	.	.	.	.	+.2	.	.	.	.	+.2	+.2	.	.	.	.	II	.
Epilobium montanum	.	.	r	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	I	.
III. D. *Vaccinio-Abietenion*																													
Fagus sylvatica a1	.	.	.	.	.	1.2	.	1.1	.	+	.	.	1.1	1.1	.	.	.	.	.	2.1	2.1	.	.	.	.	.	.	III	.
Fagus sylvatica a2	.	.	.	.	.	.	.	.	.	+	1.2	+	.	+	.	.	.	.	2.2	1.1	1.1	2.1	+	+	1.1	.	1.1		2.3
Fagus sylvatica b	+	+	+	+	.	+	+	.	+	+	1.1	+	+	+	.	+	+	+	+	.	1.2	.	+	.	.	+	1.2	V	+
Fagus sylvatica c	.	+	+	+	+	+	+	+	+	+	+	.	+	+	+	+	+	+	+	+	+	+	+	r	+	+	+		+
Athyrium filix-femina	2.2	2.2	1.2	2.2	2.2	1.2	1.2	1.2	3.2	2.2	2.2	2.2	1.2	2.2	2.2	2.2	2.2	1.2	2.2	2.2	1.2	2.3	2.2	1.2	+.2	+.2	1.2	V	3.3
Mycelis muralis	.	+	.	r	+	+	+	+	1.1	+	+	+	r	.	+	r	r	+	.	.	+	.	.	.	+	+	+	IV	.
Dryopteris filix-mas	.	+.2	.	.	+.2	+.2	+.2	+.2	+.2	.	1.2	+.2	+.2	+.2	.	.	.	.	+.2	.	+.2	+.2	1.2	+.2	.	+.2	+.2	IV	1.2
Veronica officinalis	.	+.2	.	.	.	+	.	.	.	+.2	.	.	+	+.2	+	+.2	+.2	.	+	+.2	.	.	.	.	+	.	.	III	.
Solidago virgaurea s.s.	.	+	.	+	.	.	.	.	+	+	r	.	.	+	.	.	.	.	.	+	.	.	.	.	+	+	.	II	.
Hieracium murorum	.	.	+	+.2	.	.	.	+.2	.	.	.	.	.	.	+	.	.	.	.	.	+	.	r	.	+.2	+	.	II	.
Melica nutans	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	+.2	.	+.2	+.2	.	I	+.2
IV. Ch., *D. *Piceion excelsae*																													
Picea abies a1	+	1.1	1.1	+	2.1	.	1.1	1.1	.	+	1.1	.	.	2.1	1.1	1.1	1.1	+	.	1.1	3.1	3.4	3.4	4.4	4.4	4.4	.	V	2.1
Picea abies a2	.	.	.	.	1.2	.	+	.	+	1.1	+	1.1	.	.	.	1.1	.	1.2	1.1	1.1	1.1	+	1.1	+	.	1.1	.		.
Picea abies b	.	.	1.1	+	+	.	.	.	+	+	+°	+°	+	+	.	.	.	+	.	.	.	2.1	2.2	1.1	1.1	1.1	.	V	1.1
Picea abies c	+	+	+	+	+	.	+	.	.	+	+	.	.	+	r	1.1	+	+	r	.	+	+	1.2	1.1	2.1	2.1	.		.
Plagiothecium curvifolium	+.2	+.2	1.2	1.2	1.2	+.2	+.2	+.2	+.2	1.2	+.2	+.2	1.2	1.2	1.2	1.2	2.2	1.2	+.2	+.2	+.2	1.2	1.2	+.2	+.2	1.2	1.2	V	.
**Rubus idaeus*	+°	+	1.1	1.2	+	+	1.1	+	.	+	1.2	+	+	+	1.1	1.2	2.1	1.2	+	1.2	+	1.1	+.2	1.2	2.1	1.2	+	V	1.1
**Senecio ovatus*	1.1	1.1	1.1	1.1	2.1	+	+	+	1.1	2.2	2.1	2.1	1.1	1.1	1.1	1.2	2.1	1.2	.	1.2	.	+	+	+	+	+	.	V	+
V. Ch. *Vaccinio-Piceetea*																													
Pinus sylvestris a1	1.1	.	1.1	.	.	1.2	1.1	.	.	.	.	1.1	.	.	.	+	.	+	.	2.1	.	.	.	1.1	1.1	2.1	2.1	III	3.4
Pinus sylvestris b/c	.	.	./r	./+	./r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	./+	.	I	.
Vaccinium myrtillus	2.3	2.2	2.2	2.3	2.2	3.4	3.4	1.3	2.1	1.2	1.2	2.3	3.4	+.2	+.2	1.2	1.2	2.3	1.1	1.2	2.2	+	+.2	1.2	3.2	2.2	2.2	V	+
Trientalis europaea	.	+	+	+	.	+	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	+.2	.	+.2	+	1.1	2.1	III	.
Pleurozium schreberi	.	.	.	+.2	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	+.2	.	.	+.2	3.3	3.3	+.2	II	.
Pyrola minor	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	+	.	.	.	.	.	.	.	+.2	+	.	+.2	+.2	II	.
Melampyrum pratense fo.	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	I	.
Hylocomium splendens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	+.2	.	+.2	.	I	.
VI. Ch. *Querco-Fagetea*																													
Acer pseudoplatanus a1	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.
Acer pseudoplatanus a2	.	.	.	.	.	.	.	.	.	.	.	1.1	1.1	.	1.1	+	+	.	.	.	.	.	.	.	.	.	.		.
Acer pseudoplatanus b	+	+	.	+	.	+	.	.	.	.	.	1.1	+	+	+	+	+	+	.	.	.	.	.	.	+	.	.	IV	.
Acer pseudoplatanus c	+	+	.	+	+	+	+	+	.	+	r	1.1	+	+	.	+	+	+	.	+	.	.	.	.	+	r	.		.
Corylus avellana a2	.	.	.	.	1.2	.	.	.	.	.	.	.	.	2.2	.	.	1.2	.	.	1.2	.	.	.	.	1.2	.	.	I	.
Corylus avellana b	1.2	2.2	2.3	2.1	1.2	2.1	2.1	2.2	.	.	.	.	1.2	1.2	2.3	2.2	2.2	1.2	.	1.2	+.2	+.2	+.2	.	1.2	+.2	.	V	.
Corylus avellana c	r	+	+	+	+	+	1.1	+	+	+	.	.	+	+	.	+	+	+	r	+	+	.	+	.	.	+	.		.
Cerasus avium a2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	r	.
Cerasus avium b/c	.	.	+/.	.	./r	.	.	.	./r	.	./r	./r	.	./+	.	./r	./r	./r	./r	.	.	.	./+	./r	.	.	.	III	./r
Fraxinus excelsior a2	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
Fraxinus excelsior b/c	.	.	.	.	.	.	.	.	.	./r	./+	./r	.	.	.	.	.	.	./+	./r	.	.	.	.	.	.	.	I	.
Acer platanoides b	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.
Acer platanoides c	r	+	+	r°	r	+	+	+	.	.	.	.	+	.	.	.	r	r	1.1	.	.	.	.	.	+	.	.		.
Carpinus betulus b/c	./+	./+	.	+/+	.	.	./+	.	.	./+	.	.	.	.	.	+/.	./+	.	.	.	.	.	./r	.	./+	.	+/1.1	II	.
Ribes uva-crispa c	.	+°	.	.	.	.	r	+	r°	.	.	.	.	+	.	+	.	+	.	+	.	.	.	.	+	+.2	.	II	.
Viola riviniana	.	+.2	.	.	+.2	r	+.2	.	+	.	.	.	.	+.2	.	+	.	.	.	.	.	.	.	.	+	+	r	II	+.2
Poa nemoralis	.	.	.	.	+.2	.	.	.	.	.	.	.	+.2	+.2	.	+.2	+	.	.	.	+.2	.	.	.	.	.	.	II	.
Epipactis helleborine	.	.	.	.	.	.	.	.	+	1.1	r	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.
Mercurialis perennis	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	+	.	+.2	.	.	.	.	.	.	I	.
Ajuga reptans	.	.	.	.	.	.	.	.	.	+	.	r	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	I	.
VII. Others																													
Quercus robur a1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	2.2	1.1	1.1	.	.	.	II	2.3
Quercus robur a2	.	.	1.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.		.
Quercus robur b/c	./+	./r	./+	./+	./+	+/+	./+	./+	.	./+	.	./+	./+	./+	+/.	./+	+/+	./+	.	./+	.	./+	./+	./+	.	./+	.	IV	.
Betula pendula a	.	.	.	.	.	1.1	1.1	.	+	.	+	+	.	.	.	.	+	+	1.1	+	1.1	.	.	+	1.1	.	.	III	1.1
Betula pendula b	.	.	.	+	+	.	.	.	.	.	.	.	+	.	1.1	+	+	+	.	.	.	.	.	.	.	.	.	III	.
Betula pendula c	.	+	.	+	.	.	+	+	.	.	.	.	+	+	.	+	.	+	.	.	.	.	.	.	1.1	r	.		.
Populus tremula a	.	+	.	.	+	.	1.1	1.1	.	.	.	.	1.1	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	II	.
Populus tremula b	+	+	+	.	+	+	.	1.1	+	+°	.	.	1.1	+	.	.	.	+.2	.	.	.	.	.	.	.	.	.	III	.
Populus tremula c	+	+	+	.	+	+	2.1	1.1	+	+°	.	.	.	+	.	.	.	+°	.	+	+	.	.	.	.	.	.		.
Sorbus aucuparia a2	+	+	.	.	+	.	.	.	.	.	+	1.1	1.1	+	1.1	2.1	1.1	1.1	.	+	.	1.1	1.1	1.1	2.1	.	.	III	.
Sorbus aucuparia b	+	+	.	+	+	+	+	+	+	+	+	+	+	.	1.1	+	+	+	.	.	+	.	+	+	1.1	2.1	1.1	V	.
Sorbus aucuparia c	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	2.1	+	+		+
Salix caprea a2/c	+/.	./+	.	.	+/.	.	.	.	.	.	.	.	.	.	.	.	+/.	+/.	.	.	.	.	.	.	.	.	.	I	.
Quercus rubra a2	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Quercus rubra c	.	.	.	r	.	.	+	r	+	+	+	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	II	.
Frangula alnus b	+	.	+	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	1.1	.	+	III	.
Frangula alnus c	+	+	+	.	+	+	+	+	.	r	.	+	+	+	.	.	.	.	.	.	.	.	+	+	+	+	r		+
Sambucus nigra b/c	./r	.	.	+/r	.	.	./r	.	.	+/.	.	.	.	.	.	.	.	.	.	.	.	.	.	./r	.	.	.	I	.
Oxalis acetosella	+.2	1.2	1.2	+.2	1.2	+.2	2.2	2.2	2.2	2.2	2.3	3.3	2.2	2.2	2.2	2.2	2.2	2.2	1.2	2.2	1.2	2.2	1.2	2.2	4.4	3.4	2.2	V	2.2
Maianthemum bifolium	2.1	1.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	1.2	2.1	+	1.1	+	1.1	1.2	1.2	1.2	1.1	+.2	2.1	1.1	1.2	1.2	1.1	2.1	2.2	V	1.1
Luzula pilosa	1.2	1.2	1.2	1.2	2.2	+.2	1.2	1.2	1.2	+.2	+.2	+.2	+.2	+.2	2.2	1.2	+.2	2.2	+.2	1.2	+.2	+.2	1.2	+.2	2.2	1.2	1.2	V	1.2
Polytrichastrum formosum	.	+.2	1.2	2.2	1.2	+.2	.	1.2	+.2	+.2	1.2	1.2	2.3	1.2	2.3	2.2	2.2	1.2	+.2	1.2	1.2	1.2	+.2	1.2	+.2	+.2	1.2	V	.
Dicranella heteromalla	1.2	1.2	1.2	2.2	2.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	+.2	+.2	1.2	+.2	+.2	+.2	.	.	+.2	V	+.2
Dryopteris carthusiana	+.2	+.2	+.2	+.2	.	+.2	+.2	+.2	.	.	+	+.2	+.2	+.2	+.2	+.2	+.2	+.2	+.2	1.2	+.2	+.2	1.2	+.2	+.2	+.2	2.2	V	+.2
Plagiomnium affine	+.2	.	1.2	+.2	+.2	.	.	1.2	+.2	1.2	2.2	2.2	1.2	.	2.2	2.2	2.2	2.2	.	+.2	+.2	2.2	1.2	1.2	3.3	2.3	2.3	V	.
Carex pilulifera	+.2	+.2	+.2	1.2	1.2	+.2	.	+.2	.	+.2	+.2	+.2	+.2	+.2	+.2	+.2	+.2	+.2	.	.	.	+.2	+.2	+.2	.	+.2	+.2	IV	.
Galeopsis pubescens	r	+	+	.	r	.	+	.	+	.	.	.	.	+	+	+	+	+	.	+	.	+	+	+	+	+	.	IV	+
Agrostis capillaris	.	+	+	+.2	.	.	.	.	+.2	+°	+.2	.	+	.	+.2	+°	+°	.	+.2	+.2	.	.	.	+.2	+.2	+.2	+°	III	.
Brachytheciastrum velutinum	.	+.2	+.2	.	.	.	.	+.2	.	+.2	+.2	+.2	+.2	.	1.2	+.2	+.2	+.2	+.2	.	.	.	+.2	+.2	.	.	.	III	.
Hypnum cupressiforme	.	+.2	1.2	+.2	+.2	+.2	.	+.2	.	.	.	+.2	+.2	1.2	2.2	.	.	.	.	+.2	.	+.2	+.2	.	.	.	+.2	III	.
Pohlia nutans	.	+.2	+.2	+.2	.	.	.	+.2	+.2	+.2	+.2	+.2	1.2	.	.	.	+.2	+.2	.	.	+.2	.	.	.	+.2	.	+.2	III	.
Moehringia trinervia	.	.	+	.	+	.	+	.	.	.	.	.	.	+	+	+	+	.	.	+	.	+	.	+	+	.	+	III	+
Calamagrostis epigejos	.	+°	.	.	r°	+	.	+	+	.	+°	.	.	.	.	+.2	+°	.	.	.	.	.	.	+°	+.2	+°	r°	III	.
Sciuro-hypnum oedipodium	.	+.2	.	.	.	.	.	.	.	.	.	.	+.2	+.2	+.2	1.2	12	+°	.	.	.	+.2	1.2	+.2	.	+.2	.	III	.
Pteridium aquilinum	.	.	+	.	+.2	.	2.3	.	.	+.2	.	.	+	.	.	1.2	.	.	.	.	+	.	.	+.2	.	1.3	+.2	II	.
Lophocolea heterophylla	.	.	.	.	.	.	.	.	.	.	.	+	+.2	.	+.2	+.2	+.2	.	.	+	.	+.2	+	.	+.2	.	.	II	.
Brachythecium rutabulum	.	+.2	.	+	+.2	.	.	.	.	.	.	+.2	.	+.2	+.2	.	+.2	.	.	.	.	.	+.2	.	.	.	+.2	II	.
Plagiothecium laetum	.	.	.	.	.	.	.	.	.	+.2	.	+.2	.	.	.	.	+.2	+.2	.	.	.	+.2	.	+	.	.	.	II	.
Deschampsia flexuosa	.	.	.	.	.	.	.	.	.	.	.	+.2	+	.	.	.	.	.	.	.	+.2	.	.	.	2.2	1.2	+.2	II	.
Urtica dioica	.	.	.	.	.	.	.	.	.	+	+	r	.	+	.	.	.	.	.	.	.	.	+	.	.	.	+	II	.
Herzogiella seligeri	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	+.2	+.2	.	.	.	+.2	+.2	.	.	.	+.2	II	.
Viburnum opulus b/c	.	./+	.	.	.	.	.	.	./+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	./+	+/+	./+	I	.
Carex ovalis	.	.	.	.	+.2	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	+.2	.	.	.	+.2	.	.	.	I	.
Plagiothecium denticulatum	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	+.2	.	.	.	.	.	+.2	.	.	.	.	+	I	.
Impatiens parviflora	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	+	+.2	.	.	.	I	2.1
Juncus effusus	.	.	.	+°	.	.	.	.	.	.	.	.	.	.	.	+°	+	.	.	.	.	.	+°	.	.	.	.	I	.

Sporadic species: IV. **Luzula luzuloides* 2(+); *Lycopodium annotinum* 25, 26(+); *Moneses uniflora* 26(1.2); **V.** *Betula pubescens* a2 3(+), 12(1.1), c 3(+); *Leucobryum glaucum* 27(+); *Orthilia secunda* 25(+); *Vaccinium vitis-idaea* 25(+); **VI.** *Actaea spicata* 8(r); *Anemone nemorosa* 19, 27, 28(+); *Asarum europaeum* 8(+); *Brachypodium sylvaticum* 25, 26(+); *Carex digitata* 21(+); *Dentaria bulbifera* 14(+); *Equisetum sylvaticum* 22(+); *Euonymus verrucosa* b/c 1, 11(+); *Hepatica nobilis* 19, 21(+); *Impatiens noli-tangere* 18, 20(+); *Malus sylvestris* b/c 3(+), 26(r); *Milium effusum* 24, 27, 28(+); *Padus avium* b/c 13(r), 23(+); *Pulmonaria obscura* 8(+); *Ribes spicatum* b/c 11, 12(+); *Scrophularia nodosa* 11(r); *Tilia platyphyllos* c 8, 13, 20(r); **VII.** *Aegopodium podagraria* 11(+); *Amblystegium serpens* 12(+); *Calamagrostis arundinacea* 27(+); *Campanula rotundifolia* 25(+); *Cerastium holosteoides* 26(+); *Chamaenerion angustifolium* 14, 25(+), 26(r); *Cirsium palustre* 5(r); *Convallaria majalis* 27(+); *Cornus sanguinea* b/c 2, 13(+), 6(r); *Crataegus rhipidophylla* b/c 11(r), 12, 25(+); *Festuca ovina* 25(+); *Fragaria vesca* 25(1.2), 26(+); *Galeopsis tetrahit* 24(+); *Hieracium laevigatum* 27(r); *Hypericum maculatum* 15, 26(+); *H. perforatum* 19(r), 26(+); *Kindbergia praelonga* 23(+); *Larix decidua* a1 9, 19(1.1), 10(1.2); *Luzula multiflora* 16(+); *Lysimachia vulgaris* 17, 25(+); *Melandrium rubrum* 25(+); *Mnium hornum* 1(+); *Oxyrrhynchium hians* 8, 15, 25(+); *Padus serotina* c 9, 12, 27(r); *Poa trivialis* 2(+); *Polygonum minus* 27(r); *Polypodium vulgare* 3(+); *Polytrichum commune* 4, 15(+), 17(1.2); *Prunus spinosa* c 9, 19(+), 11(r); *Quercus petraea* a1 27(1.1), a2 27(+), c 27(+); *Ranunculus repens* 10(+); *Rhamnus catharticus* c 18(r); *Rubus nessensis* 23(+); *Rumex acetosella* 25(+), 26(r); *Sorbus aria* c 5(r); *Stellaria media* 9(r).

Distribution in the study area. To date, well-developed patches of the *Abietetum albae* association have been identified in the central part of the Cracow-Częstochowa Upland (on ten locations). They are mainly situated in the southern part of the area being studied, south of the Pilica river (Fig. 2). Only two patches were found to the north of that river (compare Hereźniak 1993 — two patches from the vicinity of the village of Dziadówki near the town of Janów). Among those ten, only the phytocoenoses from the Kaliszak reserve (location 1) covered a larger area. Patches of the *Abietetum albae* covered rather small areas (up to a few hectares) in the majority of the identified locations. They were most frequently neighbouring with acidic beech woods, rarely with poorer oak-hornbeam-linden woods or acidophilous oak forests on the one hand, and, on the other hand, with fresh coniferous pine forests of *Leucobryo-Pinetum* type, which were widely characterised in this area by Wika (1983). The upland fir coniferous forest maintained bigger patches that covered vast areas in only four locations, and these were locations no. 5 (forests between the villages of Jaroszowiec and Pazurek), no. 6 (the Wodąca River Valley), no. 8 (the village of Zabagnie) and no. 10 (the village of Trzyciąż).

Phytocoenoses of the *Abietetum albae* were best developed and represented the full spectrum of local-habitat variability; moreover, they covered dozens of hectares of forests in the broadly understood Wodąca River Valley (see Wika et al. 2000). This is the valley between small localities (villages): Smoleń, Strzegowa Poduchowne, and Złożeniec. Fir forests dominated the lower parts of the slopes on almost all of the hills, in particular, Biśnik Rock, Goncerzyca Rock, Grodzisko Chłopskie, and Grodzisko Pańskie Rocks. The very extensive, traditional use of fir phytocoenoses by local private agricultural users favoured a good state of preservation of the association being discussed. This is the so-called management with a single tree (as opposed to cutting more widely and leaving large gaps in the tree canopy), as well as using the natural processes of spontaneous forest dynamics.

Attention should be paid to the large multiple-hectare patches of the *Abietetum albae* in the vicinity of Trzyciąż and Zagórowa, which are situated mainly within the borders of State Forests. A clump of the oldest and the biggest fir specimens in the entire study area with dbh over 90 cm (see rel. 44 in Table 3 and Chapter 4) are located there. A nature reserve would be an appropriate form of protection in the case of this type of forest ecosystem and would assist in maintaining, among others, the best phytocoenoses of the *Abietetum albae*.

3.3. Peculiar character of the association in the region in the light of its variability in Poland

Forest communities of the *Abietetum albae* type occur in a significant part of Poland from the colline zone in the Carpathians on the south to the Siedlecka Upland (*Wysoczyzna Siedlecka*) on the north and from Trzebnickie Hills on the west to Roztocze on the east, as it is in the literature on the subject: Dziubałtowski 1928; Dziubałtowski, Kobendza 1933, 1934; Izdebski 1959, 1963; Zarzycki 1963; Fabijanowski, Zarzycki 1965; Grodzińska, Pancer-Kotejowa 1965; Pacyniak 1966; Zaręba 1971; Fijałkowski 1973, 1993; Święs 1974a, b, 1982, 1983, 1985; Dzwonko 1977, 1986; Matuszkiewicz J. M. 1977, 2005; Jost-Jakubowska 1979; Krzemińska-Freda 1979; Macicka, Wilczyńska 1990; Głazek, Wolak 1991; Izdebski et al. 1992; Hereźniak 1993; Macicka-Pawlik, Wilczyńska 1995; Stachurska 1998; Brzeg, Rutkowski 2004; Marciniuk, Wierzba 2004; Kopeć 2006; Matuszkiewicz J. M., Kowalska 2007; Orzechowski 2007; Towpasz, Stachurska-Swakoń 2010; Barć 2012, as well as in many other papers. In spite of this, problems of the geographical differentiation of the association have not been undertaken by many researchers (Matuszkiewicz J. 1977, 2005; Brzeg, Rutkowski 2004; Matuszkiewicz W. et al. 2012). Matuszkiewicz J. (1977) examined all of the earlier and contemporary materials of that time that were related to the upland fir coniferous forests and proposed that at "the centre of the range" of the association (i.e. within the typical shape) three local shapes can be distinguished: sub-Carpathian, sub-Roztocze and sub-Holy Cross. At that time, he did not give them the rank of regional status and all of the other documentations, among others, from southern Wielkopolska and from southern Mazovia (*Mazowsze*), he treated as representing the so-called "edge shapes," which were more or less poorer and distant from the types being described. On the other hand, Brzeg and Rutkowski (2004) treated the *Abietetum albae* shapes from Trzebnicko-Ostrzeszowskie Hills (*Wzgórza Trzebnicko-Ostrzeszowskie*) and adjacent areas of the Oleśnicka Plateau (*Równina Oleśnicka*) as an independent Silesian-Wielkopolska variety of this association. They also suggested the need to raise the three mentioned local shapes to the rank of regional varieties (sub-Carpathian, sub-Roztocze and sub-Holy Cross), which were distinguished by Matuszkiewicz J. (1977). Matuszkiewicz J. M. (2005) investigated the sub-Carpathian, sub-Roztocze and sub-Holy Cross varieties, but still treated the fir forests from the other parts of the country as borderland. Six separate geographic varieties of the association, in which the status of a few needed verification, have been recently mentioned by Matuszkiewicz W. and others (2012). Some authors have treated the fir coniferous forests from the foothills of various Carpathian ranges as independent basal syntaxa, such as *Dryopterido dilatatae-Abietetum*, *Vaccinio myrtilli-Abietetum*, or "the community" *Abies alba-Rubus hirtus p.p.*, or *Abies alba-Oxalis acetosella* *p.p.* (e.g. Staszkiewicz 1973; Święs 1982, 1983, 1985; Dzwonko 1977, 1986; Stachurska 1998; Towpasz, Stachurska-Swakoń 2010), and others, for example, Barć (2012) included them into the range of the lower montane spruce-fir forest *Abieti-Piceetum* (*montanum*). On the other hand, Zaręba (1971) proposed that the fir forests form the Kozienicka Primaeval Forest (featured with small share of spruce, among others) be called the *Querco-Abietetum* association and placed them clearly in the *Vaccinio-Piceion* (=*Piceion excelsae*) alliance.

In the light of the above-mentioned information, the issue of how to solve the problem of the regional status of the association in the area of the central part of the Jurassic area, which is located in the transitive position between the areas of the units that were proposed in the previously presented book in the rank of geographic varieties: Silesian-Wielkopolska, Holy Cross, Subcarpathian, and Mazovian (in the sense of "the edge shape" from Mazovia by Matuszkiewicz J. (1977)) seems very interesting. Some exemplary materials, which document the floristic composition and differentiation of the *Abietetum albae* at the rank of subassociations, have been compiled in a shortened synthetic table (Table 5) in order to explicate this problem. The materials came from different regions and subregions within the entire range of the association in Poland. A set of conclusions, which is important for the general knowledge concerning variability of the upland fir coniferous forests in our country, can be formulated after this table has been analysed. These conclusions permit the peculiar character of this association in the area of our study to be explained.

Therefore, it seems reasonable to distinguish up to six separate units of the *Abietetum albae* that are regionally differentiated at the rank of geographic varieties (geographic races) within the entire Polish biochore of this unit (Fig. 1). These are the varieties: Silesian-Wielkopolska, Jurassic, Subcarpathian, Holy Cross, Roztocze, and Mazovian (see Matuszkiewicz J. M. 2005; Matuszkiewicz W. et al. 2012). All of them have well-manifested floristic characteristics that are both positive and negative; they also have demonstrated sets of combined distinguishing species for groups of two or more varieties.

The Silesian-Wielkopolska variety (see Brzeg, Rutkowski 2004) occurs in the area of Trzebnicko-Ostrzeszowskie Hills and in adjacent areas of postglacial valley of the Barycz river and Opole Silesia within the north-western part of the natural upland-lowland range of the fir and spruce (col. 1—6 in Table 5). It revealed the almost exclusive presence of *Chamaenerion angustifolium*, *Hypnum jutlandicum*, *Rubus gracilis*, *R. plicatus*, *R. schleicheri,* and *R. sprengelii*. Some of the species mentioned before, also occurred sporadically in other varieties; however, in the majority these are absent. *Carex pilulifera* and *Hypnum cupressiforme* reach the optimum of their occurrence in that variety of the association.

Species combined with the Jurassic variety, which rarely occurred in the other areas, were *Deschampsia flexuosa*, *Lophocolea heterophylla*, *Molinia caerulea*, *Plagiothecium curvifolium*, *Pohlia nutans*, *Pseudoscleropodium purum*, and *Sciuro-hypnum oedipodium*. The share of *Agrostis capillaris* unites the Silesian-Wielkopolska and Jurassic varieties with the Holy Cross and Mazovian varieties. *Quercus petraea* had a similar value but lacked Jurassic fir coniferous forests. These two species were distinctly absent from the Subcarpathian variety, in which they occurred only sporadically. The lack of: *Huperzia selago*, *Moneses uniflora*, *Orthilia secunda* and *Pyrola minor* was a negative feature of the Silesian-Wielkopolska variety. Brzeg and Rutkowski (2004) noted the subatlantic character of that variety and its strongest (in the country scale) connections with acidophilous oak forests from the *Quercetea robori-petraeae* class. These authors simultaneously stressed the weak state of the preservation of the association in these regions, which was caused by forest management that promoted pine at the cost of fir and spruce. Patches of that type of association took the really edge position within the entire range of the *Abietetum albae* in Poland and their preliminary inclusion into borderland shapes by Matuszkiewicz J. (1977) was an appropriate procedure at that time and was reasonable at that level of the advancement of the studies.

Table 5 illustrates the significant separateness and peculiarity of the upland mixed fir coniferous forest in the area of the central part of the Cracow--Częstochowa Upland. The newly distinguished Jurassic variety (col. 7—11), as it was mentioned, has a set of common floristic features shared with the Silesian--Wielkopolska variety (among others a share of *Plagiothecium curvifolium*, *Pohlia nutans*, and *Sciuro-hypnum oedipodium*, as well as a grass *Deschampsia flexuosa*). The specific character of the variety was underlined by species that reached the optimum of their occurrence within the range of upland fir forests such as *Acer platanoides* in the lower layers of the forest; *Brachytheciastrum velutinum* and *Cerasus avium*, mainly in the herb layer and in up-growths and *Galeopsis pubescens* and *Ribes uva-crispa*. *Corylus avellana* is a species that is common to the Jurassic and Subcarpathian varieties; it is distinctly rarer in the varieties from the Holy Cross Mts. region, Roztocze and Mazovia, and is practically absent from the Silesian-Wielkopolska variety. *Senecio ovatus*, which was in optimum of its occurrence in the Jurassic and Subcarpathian varieties, had only the status of sporadic species in the Holy Cross variety and was absent from the Roztocze as well as Mazovian varieties. *Viola riviniana*, which joined the Jurassic and Mazovian varieties, revealed an interesting spectrum of occurrence. A negative feature of the Jurassic variety (and also the Subcarpathian variety) is the total lack of *Dicranum polysetum*, which occurred quite often in the Silesian-Wielkopolska, Roztocze, and Mazovian varieties. This moss can also be an indicator of the degree of transformation in patches of fir forests that have been deformed by pine planting.

The Subcarpathian variety was specific in character (Table 5, col. 12—19). It probably also included a separate submontane altitudinal form of the *Abietetum albae* association. The species that distinguished it most reached lower degrees

Table 5. Regional and ecological differentiation of *Abietetum albae* Dziubałtowski 1928 in Poland

Successive no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Number of relevés	10	7	11	45	8	10	24	5	5	5	27	16	25	7	11	5	7	6	13	56	18	17	41	92	7	15	19	11	46	98	14	10	16	23
Subassociation	typ	typ	typ	typ	cir	cir	typ	typ	cir	cir	cir	typ	typ	typ	typ	typ	cir	cir	cir	typ	typ	cir	cir	typ	typ	typ	cir	cir	cir	typ	typ	typ	cir	typ
I. Ch., *D. *Abietetum albae*																																		
Abies alba a	V	V	V	V	IV	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Abies alba b/c	V	V	V	V	IV	V	V	IV	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
**Sambucus racemosa* b/c			II	I		III	V	I	IV		IV	+	II	I	II	II	III		IV	III	V	V	III	r	III			IV	I	I	III	+	I	III
Dryopteris dilatata (reg.)	V	V	V	I	IV	V	V	I	II	III	V	V	III	IV	III	I	II	V	II	IV	I	III	II	III	IV	+	II	III	IV	r	I		III	III
**Rubus hirtus*	V	III	IV	II	III	V	IV		I		III	II	V	V	IV	V	V	V	V	IV	V	V	V	II	IV	I		IV	I	I				
**Atrichum undulatum*	I	II	I	+	III	III	IV	I	IV	II	V	II	II	II				III	II	II	III	IV	IV	II		I	I	III	III	II	II	II	IV	
**Rubus pedemontanus*	V	III	II	II	III	I	V	IV	III	III	V	II								IV			V	II					I	IV			II	
Thuidium tamariscinum	II	III	II	II	II	III	II	II	I	II	II	IV								II	II	III	III	II		+	I	+	IV	I	III	II	IV	
**Cruciata glabra*							I				I	II						IV	+	I			+	II		III	II	II	IV	I				
II. D. reg. *A.a. circaeetosum alpinae*																																		
Carex pallescens	I	II	+	r	I	I	+	I	II				I						II	r			IV	r					r	III	II	I	IV	
Juncus effusus	I	I					+		I		I	+							II		+	I	IV							I	II		IV	
Viola reichenbachiana	II	I		II	IV	III		I	V	III	III						III	V		II	+	II	IV	III	I	III	IV	III	V	II		II	V	
Gymnocarpium dryopteris				r		II			I	II	IV							I	I	II		III	IV	+	I		r	III	IV	+			IV	I
Galeobdolon luteum (D. Suball.)	+	I		r	I	+	r				III	II	r		I	I	V	IV	II	II	III	IV	III	III	II	III	III	III	IV	I	+		III	+
Deschampsia caespitosa		I		I		II	I	II	I		II		r				III	I	II	I	I	III	+	+				II	II	II	+	II	IV	
Festuca gigantea	I			r	II	I	+	I	II		III			I					IV			I		r				III	I		+	+	III	
Phegopteris connectilis					II	+			III		II		I				I	I		I	+	II	III	+			r		II	+			II	
Circaea alpina				+	I	II					II									I		II	III	I			II	V	V	r				I
Epilobium montanum					I	+	r		I		I	+						IV					II	I			II	+	III	I				+
Eurhynchium angustirete (D. Suball.)						+			I	V	II	II			I			V		I	II	II	III	II		+	II	IV	IV	I		+	I	
Geranium robertianum							r			V	II				I		I		I	+		I	II	+	I			III	IV	r			I	
Plagiomnium undulatum											II	+								+	II	I	III	r		I	+	+	III	+			+	
Galium odoratum										III	IV					I		II		r	+		I	r			III	III	I	r				
Urtica dioica			+		I	+	+	I	I	IV	II		r							r	+			r	I	+	I	IV	III	+			I	
Paris quadrifolia											II	+					II			r	+		r	r				II	I	r				
Circaea lutetiana										I	II						II			r							II	III	I					
III. D. regional varieties																																		
Quercus petraea a	V	III	II	II	II	III	I	I	II	I	r									I	II	I	r	r				+	r	III	II	V	III	
Quercus petraea b/c	V	III	III	III	II	II	I		II	I	r									+	II	I	II	+	II		r	II	+	III	II	IV	IV	
Hypnum cupressiforme	III	II	IV	+	II	III	II		I		III	I								+			III		III	II	I		+	II	+	I	III	
Agrostis capillaris		I	IV	+	I	III	II	II	III		III	II								II		I	III	r		I	+			I	III	II	V	
Chamaenerion angustifolium	III	III	III	r	I	II	+		I		I	I	r	I	I			I	+	+			III	r						I				
Rubus plicatus	+		III		II	II	I																											
Rubus sprengelii	II		I		II	II																												
Hypnum jutlandicum	III	II			I																													
Rubus schleicheri			I			II																												
Rubus gracilis			II			I																												
Pohlia nutans	III	V	IV		II	II	V	III	II		III		I	I					II						II			I		II	II	I		
Plagiothecium curvifolium	I	III	V		III	V	V	IV	II		V			III																I				
Deschampsia flexuosa	III	III	IV	r	II	IV	IV	II	I		II			II																		I		
Lophocolea heterophylla	I	II	III		II	II	III	I	II		II									+					III			II						
Sciuro-hypnum oedipodium			V		II	IV	V	I	III	II	III																							
Calamagrostis villosa	II	I	+		I		r	I	I											r														
Pseudoscleropodium purum			IV		II	II	I	II	I																					+				
Corylus avellana b/c				r		I	IV	I	II	V	V	IV	I	III	II		III	II	III	I	I	I		II	II	I		II	+	I	II			II
Senecio ovatus			+		I	II	III				V		II	IV	I			II	II		I	I												
Poa nemoralis	+						I		II		II		+	II		I		II	II	+			+					+		+				
Cerasus avium b/c	+					+	II				III	I			I	I			+	r	I	+		r	I			+						
Viola riviniana	+			r		I	II			III	II	+																	r	II	II	II	+	
Brachytheciastrum velutinum							II	I	I	I	III											I												
Acer platanoides b/c							I			I	III									r		I				I				r				
Ribes uva-crispa c										III	II																						+	
Anemone nemorosa				I		I	+			II	+	+	+				III	IV		I	III	I	II	II		IV	III	IV	III	II		III	III	I
Ajuga reptans				r	I				II	III	I	I					I	IV		I	+		II	II		I	II	II	III	II	+	+	+	
Fragaria vesca		I		I			+		III		+	IV			I			V		I		+	IV	III	III	II	II	IV	V	IV	I	I	III	I
Hieracium lachenalii				I			r		II			III	r							I		I	II	II	I	+		II	II	III	+		I	
Potentilla erecta		I				I			I			II								I			II	I		II	I	+	I	II	II	+	II	
Polytrichum juniperinum									I			II											III	I		II	I		I	II				
Luzula luzuloides											r	II	r	I	IV			I	II											r				
Carex brizoides													III				I		II															
Carex pilosa												I	r			I	III	II																
Senecio hercynicus													I		I		I	II	II															
Polypodium vulgare											r	III			IV					+			I	+					r	r				
Prenanthes purpurea												I			I			I																
Gentiana asclepiadea												I			II			II																
Polytrichum commune	+				I			I	I		I	I								II			V			I	+		r	II	+		I	
Rhizomnium punctatum																				I	+	I	III											
Polygonatum verticillatum							+					+								I	I	I	I						r					
Plagiochila asplenioides												I						III		I	+	III	II	II				+	IV				+	
Euphorbia amygdaloides																								I					II					
Daphne mezereum				r																				+				II	II					
Veronica chamaedrys				r					I			II			I			II		+			+	I		II	I		IV	II			I	
Hepatica nobilis				r							+									r		+	r	II		I	+	II	III	I		+	+	
Lycopodium annotinum			+	r		+	+		I		+	I			I			II		I	+		II	IV	V	III	III	II	V	III	II		II	II
Calamagrostis arundinacea		I	III	I	II	I	I	I	II		r			I	I					+			+	I	III	I	r	III	I	III	V	II	III	III
Festuca ovina	+	I	+			I			I		r	I	r						+	+				I	III	+	I	I	r	II	II	I	II	I
Melica nutans	I	II	+	+	II	I	r		III		I		r				II			+	I		+	II	I			III	II	II	III	III	IV	II
Convallaria majalis	+			r		+	r	I	I		r									r				r		+		+		II		+		III
Agrostis canina						+			I																						II	+	III	
IV. D. *Vaccinio-Abietenion*																																		
Fagus sylvatica a	I	I	II	r	IV	III	IV		II		III	II	II		V	V	II	I	II	II	II	III	I	I	IV	I	+	III	II	+		I	I	
Fagus sylvatica b/c	I	I	III	I	IV	III	V	I	III		V	IV	III	III	V	IV	I	V	II	III	II	III	II	IV	V	I	I	V	V	II	+	II	I	
Mycelis muralis	II	II	IV	III	IV	III	III	I	IV	V	IV	IV			III	I		V	+	II	III	III	V	III	III	II	II	IV	V	III	I	+	V	I
Carex digitata	II	II		II	III	I	r		II	III	r	III		I	I			V		II	I		+	II	V	V	III	V	V	II	IV	III	V	II
Athyrium filix-femina	I	I		+	II	IV	V	I	IV	II	V	II	IV	IV	I	III	V	IV	V	IV	V	V	V	II	II	III	II	III	IV	II	II	II	V	I
Dryopteris filix-mas	+	I		+	II	II	I		I	IV	IV	III	II	II	I	IV	V	IV	III	+	II	II	V	III	I	II	II	IV	V	I	I	I	IV	
Veronica officinalis	+			I	I	+	I		I		III	III						V		I	II	+	V	II	I				IV	III	II	II	II	
Hieracium murorum	II		+	I		I	+		I		II	II	+	I	III	II	I	V		II	I	II	IV	III	III	II	II	III	III	III	III	I	I	
Solidago virgaurea s.s.				r		+	I				II					I		I		r	+		+	I		+	+	+	+	I		+		
Galium rotundifolium	I	III		I	III										I			V					+	r					r					
IV. Ch., *D. *Piceion excelsae*																																		
Picea abies a	IV	V	V	V	V	V	V	V	II		V		II	II	I	I			I	I	+	II	I	IV	V	IV	IV	IV	III	I	III	II	II	III
Picea abies b/c	V	V	V	V	V	V	V	III	V	I	V	II	II	II	II		I		II	II	I	II	II	V	V	IV	IV	IV	V	II	V	V	V	IV
**Rubus idaeus*	III	II	IV	II	IV	V	V	III	V	V	V	I	II	II	I	II	III	I	V	V	V	V	IV	II	V	I	+	V	V	II	III	IV	IV	
Blechnum spicant				r				I	I			+	II					I					I							+				
Sphagnum girgensohnii						+			I				r					I						r	I					+				
Moneses uniflora							+				r	+						II					r	r					r					
Huperzia selago												I			I			IV			+		I	+	I				I		+			
V. Ch. *Vaccinio-Piceetea*																																		
Pinus sylvestris a	IV	V	V	r	V	IV	III	V	II	II	III	II	I	III	II		I		+	I	II	II	I	III	V	I	+	II	II	III	V	IV	IV	III
Pinus sylvestris b/c			V	IV	I	IV	II		I		I	II		I					+	I			I	I	III	III	III	I	I	III				
Betula pubescens a			+	r					I		+											+		r			+				II			
Betula pubescens b/c		I		I	II		r	I	II		r									r			II	r	I	+	I		r	II	II		II	
Juniperus communis b/c					I		r		I			+			I			III		r			r	+		I	I		I	I	II	+		
Vaccinium myrtillus	V	V	V	V	V	V	V	V	V	I	V	V	V	III	V	III	II	V	IV	V	V	V	IV	V	V	V	V	V	IV	V	V	V	V	V
Pleurozium schreberi	I	III	V	IV	III	IV	IV	III	II		II	V	I	I	IV			V		II	II	II	V	V	V	V	V	III	IV	V	IV	III	IV	IV
Trientalis europaea	+	III	IV	II	V	V	V	V	V	I	III		I							+			I	IV	IV	V	V	IV	III	V	IV	IV	V	V
Hylocomium splendens		I	IV	r	I	IV	I	II			I	III			I			IV		II		+	III	IV	I	V	V	I	III	III	III	+		IV
Melampyrum pratense fo.			II	I							I	I								I	+		r	II	III	III	III	+	I	IV	II			I
Dicranum scoparium fo.	II	III	III	I	II	+	+					IV			V			IV		II	I	III	II	II	II			II	I	II	II	+		
Leucobryum glaucum	II	II	II	I	I	II	r	I			r	III	II	II	V			I		I			+	+	III	I	I	+	r	I	+			+
Dicranum polysetum		II	II	II	I			I												r			III	II	V	+	II	+	I	II	III	+	+	+
Ptilium crista-castrensis		I	III	+	II		I								I			I					+	II	I	II	II		I	r	I			+
Vaccinium vitis-idaea	+	I	II	I	II		I	I	I		r	+												+	I	III	I		r	II	II	+	+	
Lycopodium clavatum					II	+						II								+			r	I	I	+	r		r	I			+	
Orthilia secunda							r				r	II						II		r			II	I					I	I				
Pyrola minor							I				II	I						II		r			I	+					+	+				
VI. Ch. *Querco-Fagetea*																																		
Carpinus betulus a	II			r		+	r	I	II							I	III			r	+	+		r	II			I	r	II	IV	II	II	+
Carpinus betulus b/c	III	II		II	I	II	I	I	II	III	II	I				II	I		II	+	+	+	r	II		II	II	II	I	III	III	III	IV	II
Acer pseudoplatanus a			+				+				I		r									I				+			r					
Acer pseudoplatanus b/c			+	r	I	+	I		II		IV		r	I		II	I		II	r	II	I	+			I	r	II	+	r				II
Milium effusum			II	I	I	III	II	I		V	+		II	II			III		II	+		+	+	r	I	I	II	V	I	+	+			II
Equisetum sylvaticum				r		I	r	I	I		r	I	I				II		II	+	I	II	r	+		II	II			+			+	
Carex remota	+						r												I	r	+	II	+							r		+	II	
Impatiens noli-tangere	+							I		V	+			II		I	III		I	r	+	I	+					+	I					
VII. Others																																		
Quercus robur a	+	II	+	I	II	II	IV	IV	II	II	II		III		I	II	III		IV		II	I				I	II	II		III	II	II	II	II
Quercus robur b/c			V	II	II	IV	IV	IV	II	II	IV	III	III	I	II		I		IV	I	II	I		r	V	II	II	IV		IV	III	II	IV	IV
Betula pendula a	II	II	II	+		III	II	I	I		III		+		II	II			II	II	II	II		II	I	I	I	+	r	II	II	III	III	
Betula pendula b/c	III	III	V	I	II	IV	II		III		III	IV	II	I	II				III	I	II	I		r		I	II			IV	II		+	
Populus tremula a							I	I			II					I	II			II	I	I	r	r		+	I	II	r	II	I	+	+	
Populus tremula b/c			+	r	I		III	I	I	I	III	II	I			II	I		II	I	II	III		r	I	I	I	II		III	+	I	I	
Larix decidua a	IV	III	II		II	II	+		I		I		r	I			I		III	II			+	+					I					
Larix decidua b/c	II	II	II		I	II	+		I					I		I			I															
Sorbus aucuparia a2	II	I	+		I		II	III	III		III	V	I		III	I	I	II	+	V	I		V	IV					III	IV	II	+	I	IV
Sorbus aucuparia b/c	V	V	V	V	V	V	V	V	V	V	V	V	IV	V	IV	II	III	II	V	V	IV	V	V	IV	V	III	IV	V	V	IV	V	V	V	V
Frangula alnus b/c	III	IV	V	II	V	IV	IV	V	IV	I	III	II	IV	II		II	I		IV	II	II	II	I	III	IV	IV	III	V	III	III	V	IV	V	III
Sambucus nigra b/c	I	I			I					IV	I		+	III	I			II	I			I										+	II	
Oxalis acetosella	V	V	V	IV	V	V	V	IV	V	V	V	IV	IV	IV	II	V	V	V	IV	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Maianthemum bifolium	V	V	III	IV	IV	IV	V	IV	V	V	V	V	V	III	V	III	V	V	V	V	V	IV	V	V	V	V	V	V	V	V	V	V	V	V
Luzula pilosa	V	V	IV	IV	V	V	V	V	IV	V	V	V	IV	II	III	III	III	V	IV	IV	V	V	V	V	V	V	V	V	IV	V	V	V	V	III
Dryopteris carthusiana	V	IV	V	III	II	V	V	V	IV	II	V	V	IV	II	III	III	IV	IV	II	IV	IV	IV	V	V	V	III	II	V	V	III	IV	IV	V	V
Polytrichastrum formosum	V	V	V	IV	V	IV	V	V	IV		V	V	IV	II	V			V	III	IV	IV	IV	II	V	V	III	III	IV	V	IV	V	V	V	
Plagiomnium affine		II	V	I	IV	V	IV	IV	IV	II	V	III		I				IV		I	IV	III	III	II	V	II	II	V	IV	r	IV	III	V	
Pteridium aquilinum	II	III	V	II	IV	III	II	V	IV	V	II	II	III	I					III	I	I		+	II	III	II	II	I	II	IV	V	IV	V	II
Moehringia trinervia	IV	II	IV	II	V	V	I	II	IV	IV	III	+	I	I	I	I	I	I	II	I	II	III	II	I	III	I	II	V	III	II	III	IV	V	I
Carex pilulifera	V	V	V	II	IV	V	III	III	I		IV		II	II				II	I	I	+	I	III	+	III			+	r	II	IV	III	III	
Dicranella heteromalla	IV	II	II		I	V	V	II	I		V	II	III	V	I				II	II	+	+	r					+		I		+	I	
Calamagrostis epigejos	V	V	V	II	IV	V	III	I	I		III								II				V	r					r		I	+	II	
Plagiothecium laetum			+			I	II		I		II	I	II						II	II	I	II		r				II			II	I	I	
Rumex acetosella	+	I	III	I			r				+	I											I	r					+	II	+			
Plagiothecium denticulatum	I	II	+			+	II		I		I	+		II	II					I	I	I	II							I				
Anthoxanthum odoratum	I	I	+	II	I	I			II			I											I	r						II			I	
Carex leporina						I	II		I		I		I						II		+										+		III	
Galeopsis tetrahit	+				II	III					r		+						I		IV	I						+			+	II	I	
Luzula multiflora			+			+	+		I		r		r						II				I	r						II	+		I	
Lysimachia vulgaris				+	I	+		II	II		+		I	I					II	+		II	+	r		II	I		r	II	I	I	+	
Brachythecium rutabulum	+						+		I		II	+								II	II	II			I	+	I	II			I	+	II	

Explanations: **cir** — *Abietetum albae circaeetosum alpinae*; **typ** — *A.a. typicum*; table shortened; **col.** — column

Specification of data compiled and compared in Table 5

The Silesian-Wielkopolska variety:
1. Macicka-Pawlik, Wilczyńska (1995): Table 1.
2. Macicka, Wilczyńska (1990): Table 15, rel. 1—3, 5, 8, 9; Table 17, rel. 28.
3. Brzeg, Rutkowski (2004): Table 1, rel. 1—11.
4. Matuszkiewicz J. (1977): Table 3, col. 12.
5. Macicka, Wilczyńska (1990): Table 15, rel. 4, 6, 7, 10, 11; Table 16, rel. 5, 9; Table 17, rel. 29.
6. Brzeg, Rutkowski (2004): Table 1, rel. 12—21.

The Jurassic variety:
7. Barć et al. (orig.): Table 3, rel. 1—24.
8. Hereźniak (1993): Table IX, rel. 6—9; Table XV, rel. 1.
9. Hereźniak (1993): Table IX, rel. 1—5.
10. Kopeć (2006): Table 2, col. 3.
11. Barć et al. (orig.): Table 4, rel. 1—27.

The Subcarpathian variety:
12. Matuszkiewicz J. (1977): Table 3, col. 6.
13. Stachurska (1998): Table 9, rel. 1—25.
14. Barć (2002): Table VIII + IX.
15. Dzwonko (1986): Table 15, col. 3.
16. Towpasz, Stachurska-Swakoń (2010): Table 11, rel. 5, 8, 9, 11, 12.
17. Towpasz, Stachurska-Swakoń (2010): Table 11, rel. 1—4, 6, 7, 10.
18. Dzwonko (1986): Table 15, col. 2.
19. Stachurska (1998): Table 9, rel. 40—52.

The Holy Cross Mts. variety:
20. Matuszkiewicz J. (1977): Table 3, col. 8.
21. Głazek, Wolak (1991): Table 30, rel. 1, 2, 5, 7, 16—19, 21, 22, 24—28; 30, 32, 34.
22. Głazek, Wolak (1991): Table 30, rel. 3, 4, 6, 8—15, 20, 23, 29; 31, 33.
23. Matuszkiewicz J. (1977): Table 3, col. 10.

The Roztocze variety:
24. Matuszkiewicz J. (1977): Table 3, col. 7.
25. Izdebski et al. (1992): Table 14, rel. 115, 117—122.
28. Izdebski et al. (1992): Table 14, rel. 106—114, 116, 123.
29. Matuszkiewicz J. (1977): Table 3, col. 9.

The Mazovian variety:
30. Matuszkiewicz J. (1977): Table 3, col. 11.
31. Jost-Jakubowska (1979): Table 1, rel. 3, 5—17.
32. Krzemińska-Freda (1979): Table 1, rel. 17—26.
33. Krzemińska-Freda (1979): Table 1, rel. 1—16.
34. Marciniuk, Wierzba (2004): Table 1, col. 8 + 9.

Specification of data compiled and compared in Table 5

The Silesian-Wielkopolska variety:
1. Macicka-Pawlik, Wilczyńska (1995): Table 1.
2. Macicka, Wilczyńska (1990): Table 15, rel. 1—3, 5, 8, 9; Table 17, rel. 28.
3. Brzeg, Rutkowski (2004): Table 1, rel. 1—11.
4. Matuszkiewicz J. (1977): Table 3, col. 12.
5. Macicka, Wilczyńska (1990): Table 15, rel. 4, 6, 7, 10, 11; Table 16, rel. 5, 9; Table 17, rel. 29.
6. Brzeg, Rutkowski (2004): Table 1, rel. 12—21.

The Jurassic variety:
7. Barć et al. (orig.): Table 3, rel. 1—24.
8. Hereźniak (1993): Table IX, rel. 6—9; Table XV, rel. 1.
9. Hereźniak (1993): Table IX, rel. 1—5.
10. Kopeć (2006): Table 2, col. 3.
11. Barć et al. (orig.): Table 4, rel. 1—27.

The Subcarpathian variety:
12. Matuszkiewicz J. (1977): Table 3, col. 6.
13. Stachurska (1998): Table 9, rel. 1—25.
14. Barć (2002): Table VIII + IX.
15. Dzwonko (1986): Table 15, col. 3.
16. Towpasz, Stachurska-Swakoń (2010): Table 11, rel. 5, 8, 9, 11, 12.
17. Towpasz, Stachurska-Swakoń (2010): Table 11, rel. 1—4, 6, 7, 10.
18. Dzwonko (1986): Table 15, col. 2.
19. Stachurska (1998): Table 9, rel. 40—52.

The Holy Cross Mts. variety:
20. Matuszkiewicz J. (1977): Table 3, col. 8.
21. Głazek, Wolak (1991): Table 30, rel. 1, 2, 5, 7, 16—19, 21, 22, 24—28; 30, 32, 34.
22. Głazek, Wolak (1991): Table 30, rel. 3, 4, 6, 8—15, 20, 23, 29; 31, 33.
23. Matuszkiewicz J. (1977): Table 3, col. 10.

The Roztocze variety:
24. Matuszkiewicz J. (1977): Table 3, col. 7.
25. Izdebski et al. (1992): Table 14, rel. 115, 117—122.
28. Izdebski et al. (1992): Table 14, rel. 106—114, 116, 123.
29. Matuszkiewicz J. (1977): Table 3, col. 9.

The Mazovian variety:
30. Matuszkiewicz J. (1977): Table 3, col. 11.
31. Jost-Jakubowska (1979): Table 1, rel. 3, 5—17.
32. Krzemińska-Freda (1979): Table 1, rel. 17—26.
33. Krzemińska-Freda (1979): Table 1, rel. 1—16.
34. Marciniuk, Wierzba (2004): Table 1, col. 8 + 9.

of constancy. However, these forming a quite numerous group were practically absent in other areas. Some of them have a montane type of range and are transitive species, among others, the lower montane mixed fir-spruce forest *Abieti-Piceetum* (*montanum*). This group consisted of *Carex brizoides*, *C. pilosa*, *Gentiana asclepiadea*, *Luzula luzuloides*, *Polypodium vulgare*, *Prenanthes purpurea*, and *Senecio hercynicus*. A negative feature of this variety, which is common with the Holy Cross variety, is the total deficit of *Trientalis europaea* and a distinctly lower share of *Moehringia trinervia*. It should be pointed out that the participation of lowland species, including, for example, *Calamagrostis epigejos*, *Carex pilulifera* or *Plagiomnium affine*, is low there.

The range of the variety being discussed is the widest in comparison with the other units of that rank. This is probably because it is heterogeneous, and further studies would permit some new divisions. It occurs in all of the foothills of all of the Carpathian ranges as far as to the Bieszczady Mts. and includes the majority of forests in fir-type phytocoenoses, which have been described under different names that have appeared in this book before.

The Holy Cross variety (Table 5, col. 20—23) had relatively weak positive characteristics. This variety is distinguished by three species (*Polygonatum verticillatum*, *Polytrichum commune*, and *Rhizomnium punctatum*), and it is united with the Roztocze variety by *Plagiochila asplenioides*. These species achieve mostly lower constancy degrees. It must be stressed that currently in the Holy Cross fir forests, the decrease in specific species of the geographic race of the *Abietetum albae* association being discussed is noticeable. This particularly relates to the *Polytrichum commune*. More and more often taxa which were absent in the past, or only sporadically present, which are transitive from other varieties, are now occurring (Matuszkiewicz J. M. 2007; Matuszkiewicz J. M., Kowalska 2007), such as, for example, *Calamagrostis villosa* and *Senecio ovatus*. *Agrostis capillaris*, which has made quite regular appearances was a joint feature among the Silesian-Wielkopolska, Jurassic, and Mazovian varieties. Except for it, *Quercus petraea* (among others) *per analogiam* with the Jurassic area is rarely present. The sporadic share of *Pteridium aquilinum*, which was in general, frequent in the *Abietetum albae* in other areas, has been one of a few negative features that caught our attention. Likewise, in the Subcarpathian variety the spruce, *Picea abies*, was not so frequent a component of the forest stand.

It must be stressed that the area of the Holy Cross Mts. is the *locus classicus* of the *Abietetum albae* association (Dziubałtowski 1928; Dziubałtowski, Kobendza 1933, 1934), and in the historical sense, the variety being discussed should be regarded as the most "typical shape" of that association. This is also reflected in its floristic features.

The Roztocze variety of the association being discussed (Table 5, col. 24—29) revealed the almost exclusive presence of *Daphne mezereum*, *Euphorbia amygdaloides*, and *Hepatica nobilis*. In addition to these, *Carex digitata* (only sporadically in the Jurassic area), *Cruciata glabra*, *Fragaria vesca*, and in particular *Lycopodium annotinum*, reached a distinct optimum of their occurrence within the upland mixed fir coniferous forests. Spruce was a relatively constant component of the stand; moreover, it regenerated well in the lower forest layers. The somewhat more thermophile and also subcontinental character of that variety was strengthened by the frequent presence in the group of species that were combined with the Mazovian variety, which were usually only sporadic in the *Abietetum albae* phytocoenoses in the other areas of the country. This group consisted of *Calamagrostis arundinacea*, *Festuca ovina*, and *Melica nutans*, and was supported by a bit more widely spread taxa within the fir forests, that is *Ajuga reptans*, *Anemone nemorosa*, and *Hieracium lachenalii* among others. In the Roztocze region and in the adjacent areas of the Lublin region, there is practically a dearth of, among others, *Deschampsia flexuosa*, *Dicranella heteromalla*, *Plagiothecium curvifolium*, or *Sambucus nigra*, and in addition, numerous species that differ from the other varieties of the association as well.

In the southern area of the broadly understood Mazovia (from the Powyże Łódzkie Upland on the west to the Siedlecka Upland on the east), and therefore in the north-eastern part of the lowland-upland area of the association's range, the *Abietetum albae* was observed in the Mazovian variety (Southern-Mazovian, see Matuszkiewicz W. et al. 2012). Within the association's range it occurs almost exclusively in the presence of *Agrostis canina* and *Convallaria majalis*, and frequently occurs with the above-mentioned group of species in combinations with the Roztocze variety (col. 30—34). In spite of the fact that along with the Jurassic variety, it is frequently found in the presence of *Viola riviniana*, it is worth paying attention to quite a significant role of the elements combined with the Silesian-Wielkopolska race, that is, *Agrostis capillaris*, *Hypnum cupressiforme*, and *Quercus petraea*. This allows to notice some references to the shape of the fir forest to acidophilous grassy oak forest the *Calamagrostio arundinaceae-Quercetum petraeae*, and in particular to the lowland subcontinental mixed coniferous oak-pine forest, *Querco roboris-Pinetum* (see Zaręba 1971; Matuszkiewicz J. 1977, 2005; Orzechowski 2007; Matuszkiewicz W. et al. 2012). The share of beech, *Fagus sylvatica*, has diminished as a component of the forest stand within the Mazovian variety. Moreover, for instance *Calamagrostis epigejos*, *Cruciata glabra*, *Dicranella heteromalla*, and *Rubus hirtus*, were observed in fir forests of that area only exceptionally as sporadic species.

Marciniuk and Wierzba (2004) documented the considerably weakened "edge shape" of the variety described (Table 5, col. 34) from the Jata and Topór Forestries in the Siedlce area.

In any description of the regional differentiation of the *Abietetum albae* association in Poland, it is worth noting that its floristic characteristics of a more fertile (and wetter) section, that is, documented within all of the varieties, the *A.a. circaeetosum alpinae* subassociation (Table 5, col. 5 and 6, 9—11, 17—19, 22, and 23, 27—29, 33) was somewhat different in its varieties. With the exception of the species that differ from that subassociation in the supraregional scale, which are *Circaea alpina* (hitherto not confirmed or only sporadic in the Subcarpathian and Mazovian varieties), *Deschampsia caespitosa*, *Epilobium montanum*, *Festuca gigantea*, *Galeobdolon luteum* (the last species had a weaker diagnostic value in the Holy Cross and Roztocze varieties, where it occurred quite frequently in a typical subassociation), *Gymnocarpium dryopteris*, *Phegopteris connectilis*, and *Viola reichenbachiana*; in particular geographic races, a diagnostic role was also played by other taxa.

In the Silesian-Wielkopolska variety (to a lesser degree also in the Roztocze and Mazovian varieties) such a diagnostic value was also reached by *Athyrium filix-femina* and *Dryopteris filix-mas*, which are ferns that in general distinguish the *Vaccinio-Abietenion* suballiance in the entire spectrum of the association variability, and also apart from them, *Galeopsis tetrahit* among others (see Brzeg, Rutkowski 2004).

The list of the diagnostic species of the subassociation being in the area of our interest in the Jurassic, Subcarpathian, Holy Cross, and Roztocze varieties is completed well by *Eurhynchium angustirete*, *Galium odoratum*, *Geranium robertianum* (see Matuszkiewicz J. 1977, 2005), and *Plagiomnium undulatum*. *Circaea lutetiana*, *Paris quadrifolia*, and *Urtica dioica* (this species is in general also absent in the Subcarpathian variety) represent a similar diagnostic value (however, omitting *A.a. circaeetosum* in the Holy Cross variety).

The other two species, *Carex pallescens* and *Juncus effusus*, additionally differed from the subassociation quite well in the Subcarpathian, Holy Cross, and Mazovian varieties, but these are practically absent in the phytocoenoses that represent the Roztocze variety.

4. The structure and dynamics of fir renewal in the phytocoenoses of the *Abietetum albae* association on the chosen study plots

4.1. The differentiation of the vertical structure of the upland mixed fir coniferous forest *Abietetum albae*

The following three main layers of the forest: tree stand (a), shrubs (b) and herb layer (c) were distinguished in the vertical structure of the upland mixed fir coniferous forest *Abietetum albae* based on the studies conducted in the central part of the Cracow-Częstochowa Upland on three localities — nearby villages: Strzegowa Poduchowne (Goncerzyca), Hucisko Ryczowskie, and Trzyciąż. The number of specimens of fir *Abies alba* Mill., which played different roles, that is, the forest stand-forming role, the up-growth and the new-growth, were analysed in each of them (Fig. 6). General relationships of *Abies alba* new-growths and the moss layer (d) were also investigated.

From 5—11 mature specimens of the silver fir (on the area of 200 m^2) were observed in the tree stand on each of the particular permanent study plots, while from 0—8 (on the area of 200 m^2) were observed in the shrub layer. From 18 to 371 specimens of fir per study unit (on the area of 4 m^2) occurred in the herb layer (new-growths including seedlings) (Table 6). It means that after the conversion into the traditional units of acreage used in forestry fir occurred in the forest stand with mean density of 375 specimens/ha, in the up-growths — 192 specimens/ha, and in the new-growths (with seedlings) — on average 34 specimens/m^2 in the forest stand of the *Abietetum albae*.

Each pair of the permanent study plots (Goncerzyca I and II, Hucisko Ryczowskie III and IV, Trzyciąż V and VI) represented a different type of the vertical structure of the upland mixed fir coniferous forest (see Fig. 7):

Type 1 — Goncerzyca was characterised by a full vertical structure, which is represented by the tree stand composed of *Abies alba*, its up-growths and new-growths. The relatively high quantitative share of new-growths (c/a: 30 or 41, Table 6) fell to one mature specimen of fir in comparison with the other

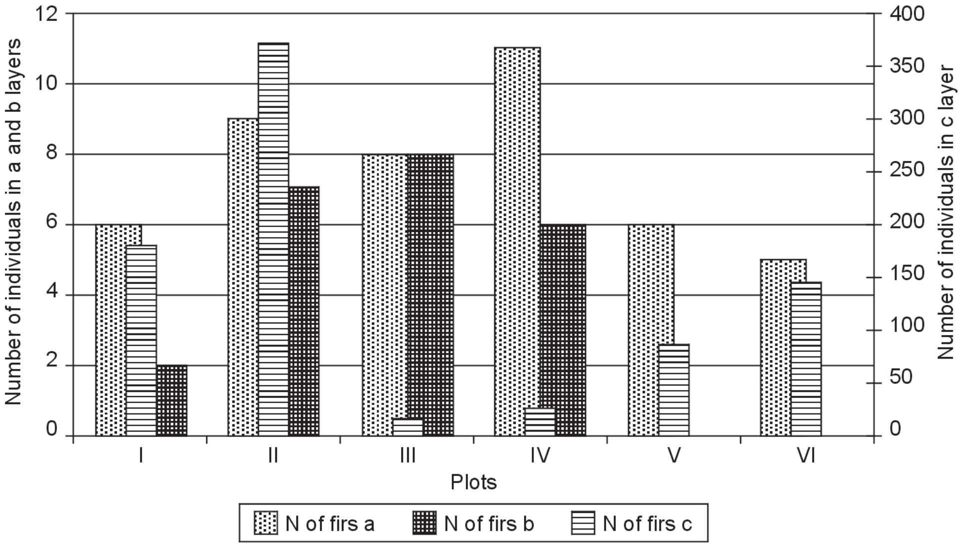

Fig. 6. The number of specimens of fir *Abies alba* forming vertical structure of the *Abietetum albae* in the central part of the Cracow-Częstochowa Upland on particular study plots (I—VI)

Explanations: **I—II** — Goncerzyca, **III—IV** — Hucisko, **V—VI** — Trzyciąż; **N** — number of specimens of fir in particular layers; **a**, **b**, **c** — main forest layers

Table 6. Differentiation of the number of silver fir *Abies alba* specimens in particular layers of the forest on the permanent study plots

No. of study plot / Layer	I	II	III	IV	V	VI	**Total I—VI**	Range I—VI	Average I—VI	Std. Dev.
N in a/200 m^2	6	9	8	11	6	5	**45***	5—11	7.5	2.3
N in b/200 m^2	2	7	8	6	0	0	**23***	0—8	3.83	1.8
N in c/4m^2	180	371	18	27	86	147	**829****	18—371	138.2	130.8
c/a	30	41	2.25	2.4	14.3	29.4	—	—	—	—
c/b	90	53	2.25	4.5	0	0	—	—	—	—

Explanations: * — on the total area of 1200 m^2; ** — on the total area of 24 m^2; **N** — number of specimens; **Std. Dev.** — Standard Deviation

two localities. The quantitative share of up-growths was different and the coefficients of the number of new-growths that fell to the number of up-growths (c/b) were high.

Type 2 — Hucisko Ryczowskie also was characterised by a full vertical structure but the share of new-growths was very low there (c/a — more than ten times lower than in Goncerzyca's new-growths), whereas the quantitative share of fir up-growths was equal to or less than the number of mature trees.

Type 3 — Trzyciąż had a poorer vertical structure, in which only the forest stand dominated by the fir, as well as the new-growths of this species were present. Up-growths were absent in that type of phytocoenosis. The relative share of new-growths (c/a) from the locality in Trzyciąż VI was similar to that from Goncerzyca I.

4.2. Species diversity in particular layers of the forest

The tree layer on the delimited permanent plots of the *Abietetum albae* association was dominated by fir. With the exception of the fir, only rowan plays a larger role as an admixture in the a_2 layer (lower sublayer) of the forest stand in the sense that it occurred on half of the six of permanent study plots that were analysed. Beech, pine, birch, and sycamore were not numerously represented. An interesting species was a single, magnificent specimen of hawthorn *Crataegus*, which grew up to the lower sublayer of the tree stand in plot IV near Hucisko Ryczowskie village.

The forest stand in the study area of the permanent plots was composed of 45 specimens of matured firs in total, which were accompanied by 19 specimens of the above-mentioned admixture of deciduous and coniferous species. Rowan was represented most numerously among admixtures on all six study plots, (12 specimens/12 ares), that is, 100 specimens/ha. Only three specimens of beech were observed (i.e., 25 specimens/ha) and single specimens of pine, birch and sycamore, as well as the above-mentioned shrub — hawthorn *Crataegus*. These occurred in the forest stand dominated by fir (Table 7).

Table 7. Species and quantitative differentiation of the forest stands of the *Abietetum albae* association that were studied (N/study plot)

No. of study plot	I	II	III	IV	V	VI
Fir	6	9	8	11	6	5
Other species	1 Be	1 Pi	1 Bi, 1 Sy, 2 Ro	2 Be, 1 Hw	3 Ro	7 Ro
Total species	2	2	4	3	2	2

Explanations: **Be** — beech, **Bi** — birch, **Hw** — hawthorn, **Pi** — pine, **Ro** — rowan, **Sy** — sycamore; **N** — number of specimens

Both (III and IV) permanent study plots from Hucisko were most differentiated in relation to the species diversity. The other four were dominated by fir specimens — in most cases there were a higher number of the specimens. However, in the case of the Trzyciąż VI study plot, it was not the number of specimens but their impressive dimensions in diameter at breast height that was interesting.

The shrub layer on particular permanent study plots of an area 200 m^2 each was built of one to six species. In total, it comprised 125 specimens of various species of trees and shrubs. Permanent plot Goncerzyca I was the least differentiated in species, where the up-growth was exclusively composed of fir, whilst plot II on Goncerzyca and plot V nearby Trzyciąż village (6 species) were most differentiated. In Trzyciąż V fir did not occur in that layer and the diversity was the result of the presence of other species (among others: shrubs and trees that produce light seeds like hazel or birch). Fir up-growths also did not occur on plot VI in Trzyciąż (Table 8).

Table 8. Species and numerical differentiation (N/study plot) of the up-growth in the shrub layer on particular study plots (I—VI)

No. of study plot		I	II	III	IV	V	VI	Sum*
Fir	Fr	2	7	8	6	0	0	23
Other species	Ro	0	16	2	1	12	15	46
	Bi	0	1	0	0	17	0	18
	Ha	0	0	0	0	11	1	12
	Be	0	1	6	2	2	0	11
	Sy	0	1	10	0	0	0	11
	As	0	0	0	0	2	0	2
	Ho	0	1	0	0	0	0	1
	Ab	0	0	0	0	1	0	1
Sum of specimens		2	27	26	9	45	16	125
Sum of species		1	6	4	3	6	2	—

Explanations: **Ab** — alder buckthorn, **As** — aspen, **Be** — beech, **Bi** — birch, **Ha** — hazel, **Ho** — hornbeam, **Ro** — rowan, **Sy** — sycamore; **N** — number of specimens; * — on total area 1200 m^2

Regarding the number of specimens, all species of the shrub layer b (except for the fir) were distinguished on plot no. V in Trzyciąż (45). There were approximately 50% fewer specimens of the up-growth, including fir, on no. II on Goncerzyca Rock, and no. III in Hucisko Ryczowskie. Only nine specimens were observed on plot no. IV in Hucisko. The lack of other components of the shrub layer, with the exception of the fir, was observed on plot no. I on Goncerzyca Rock. Rowan prevailed (46 specimens of this species) over the fir (23 specimens) and birch (18 specimens), hazel (12 specimens), beech and sycamore (11 specimens in each case) in all of the study areas on permanent plots (12 ares in total). Aspen (two specimens), as well as hornbeam and alder buckthorn (one specimen in each case) appeared sporadically. Having investigated the units used in the forestry, the numbers were as follows: 383 specimens of rowan/ha, 192 firs/ha, 150 birches/ha, 100 hazels/ha, 92 of both beeches and sycamores/ha, 17 aspens/ha and eight of both hornbeams and alder buckthorns/ha. It must be stressed that these are the values of the densities for the up-growth calculated from an area equal to the area of the data collecting that was used for the stand.

The differentiation of the shrub layer seems to be significantly poorer if only the results from the so-called inner subarea of the studies — "i" are taken into consideration (see Chapter 2), which did not cover 12 ares but 2.4 ares (Table 9).

Table 9. Species and numerical differentiation (N/study plot) of the shrub layer in the inner subarea "i"* of the permanent study plots

No. of study plot		I	II	III	IV	V	VI	Sum*
Fir	Fr	1	0	0	0	0	0	1
Other species	Ro	0	4	0	4	0	5	13
	Bi	0	0	0	0	0	0	0
	Ha	0	0	0	0	1	1	2
	Be	0	0	3	1	0	0	4
	Sy	0	0	5	0	0	0	5
	As	0	0	0	0	1	0	1
	Ho	0	1	0	0	0	0	1
	Ab	0	0	0	0	1	0	1
Sum of specimens		1	5	8	5	3	6	28
Sum of species		1	2	2	2	3	2	—

Explanations: **Ab** — alder buckthorn, **As** — aspen, **Be** — beech, **Bi** — birch, **Ha** — hazel, **Ho** — hornbeam, **Ro** — rowan, **Sy** — sycamore; **N** — number of specimens; * — on total area of 240 m^2

The reduction of the area of data collecting on permanent study plots I—VI from a total of 12 ares to 2.4 ares caused a reduction in the number of specimens in the up-growths from 125 to 28. With the exception of hornbeam and alder buckthorn, the drop in the number of specimens applied to all of the other species that formed the up-growths. The total number of species from the shrub layer did not change only on plots no. I and VI (see Tables 8 and 9). On other permanent plots not only did the total number, but also the diversity of species dropped, respectively. Therefore, the comparisons in the further part of this chapter will apply to the up-growths that occurred in the entire area of the study plots, that is, on the total area of 12 ares. Such a comparison better corresponds with the results of phytosociological studies that were done for the purposes of the present elaboration.

The herb layer that was studied on 4 m^2 within each plot consisted of a maximum 19 species of vascular plants (study plot no. V in Trzyciąż). In the majority of cases, the herb layer consisted of more than 15 species. It gathered only 11 components on study plot no. IV (Hucisko Ryczowskie). An identical combination of species was always present in the herb layer on all six of the plots in the study units: *Abies alba*, *Athyrium filix-femina*, *Oxalis acetosella*, and *Rubus hirtus et pedemontanus*. These species occurred in various quantitative proportions (Table 10).

TABLE 10. Cover and frequency of the constant components of the herb layer in the study units* on particular plots (I—VI)

Species \ No. of study plot	I	II	III	IV	V	VI	Frequency [%]
	Range of the cover [%]						
Abies alba	10—50	1—80	1—2	1—2	1—7	5—10	100
Athyrium filix-femina	10	1—5	5—7	7	5—20	5—7	46
Oxalis acetosella	1—20	1—7	2—50	2—30	1—5	1—5	92
Rubus hirtus et pedemontanus	10	2—7	1—20	5—15	3—10	5—30	62

Explanations: * — study units include four squares 1 m × 1 m, which cover four m^2 in total on each of the permanent study plots

Fir was present in all 24 of squares on six of permanent study plots that were analysed. However, its share was strongly differentiated (1—80% of cover/m^2). The other species of the herb layer were present in at least 46% of the squares that were analysed. *Oxalis acetosella* occurred the most frequently and with the highest cover in relation to the other species, with the exception of fir.

The structure of the species richness of vascular plants in the forest layers (Fig. 7) on the permanent study plots (I—VI) was, as was mentioned above, different. A forest stand was composed of two to four species/200 m^2, the shrub layer was somewhat more diversified (one to six species/200 m^2) and the herb layer was most diversified (11—19 species/4 m^2).

The quantitative structure of the species richness of vascular plants in the forest stand (a) and shrub (b) layers on particular study plots had its own specific features. This allowed the three types of species richness in the layers

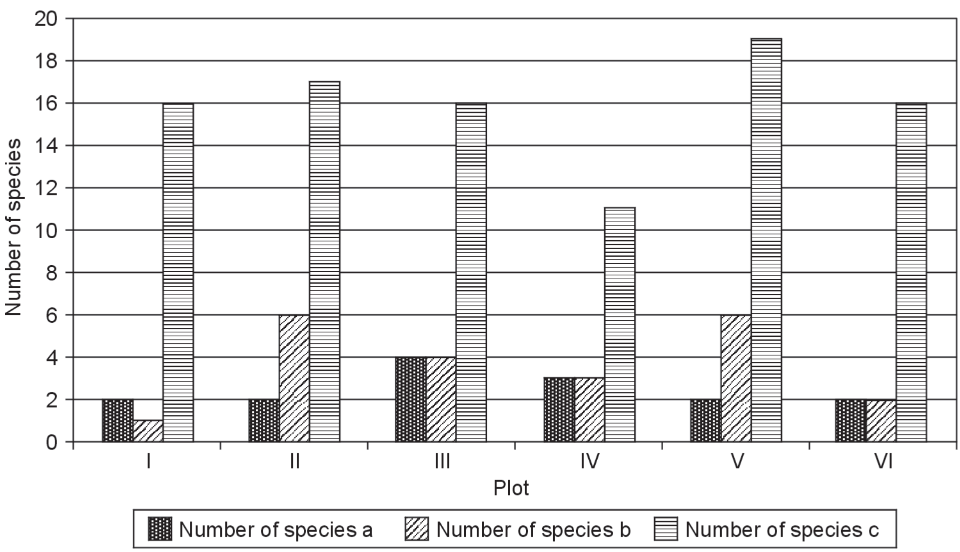

FIG. 7. Number of vascular plant species in particular layers of the forest (a, b, c)

to be distinguished. The richness of the herb layer was not a criterion of this division. In all of the types mentioned below, the herb layer (c) was always the richest in species when compared with the higher layers of the upland mixed fir coniferous forest:

Type 1 — $a_{min} < b_{med} < c_{max}$ — in which the stand was the poorest in species, the shrub layer was richer in species and the herb layer was the richest. It is represented by the permanent study plots on Goncerzyca (plot no. II) and in Trzyciąż (plot no. V);

Type 2 — $a = b < c_{max}$ — in which the richness of species in the stand and in the shrub layer were equal and the herb layer was the richest in species. It was represented by the permanent study plots in Hucisko Ryczowskie (plots no. III and IV) and in Trzyciąż (plot no. VI);

Type 3 — $a > b < c_{max}$ — in which the stand was insignificantly richer than the shrub layer, the shrub layer was the poorest in species and the herb layer was the richest. It was represented by study plot no. I on Goncerzyca.

These types did not reveal any connection with the geographic location of the study plots.

4.3. Diameter structure of the forest stand

Fir was most numerously represented in the diameter range at the breast height of 30—34 cm (but according to the classification of ranges every 10 cm — 30—39 cm) on the permanent plots that were analysed in the central part of the Cracow-Częstochowa Upland. The thickest fir trees were the least represented. Among other things, this is the result of forest management, but is also a natural feature of forests that are more advanced in the age classes in which there is a time and a place for dying specimens at the most advanced ages and also for the natural development of a new generation under the canopy of the mature forest stand (Fig. 8 and 9).

The use of the ten-centimetre ranges of diameter distribution and with the elimination of the incomplete range (8—9 cm) (see Fig. 8 and 9) allowed for distinguishing three equal ranges of thickness values in the range of 10—99 cm, and therefore, three quality categories of the diameter at breast height were observed: low, mean, and high diameter values (Fig. 10).

The fir trees on the permanent study plots in Goncerzyca had the lowest mean value of diameter, while there was a somewhat higher mean diameter in Hucisko Ryczowskie and the highest value was observed in Trzyciąż (Table 11).

The forest stand with trees with the smallest diameters from among all of those studied (mean diameter 22.5 cm) occurred on the permanent plot

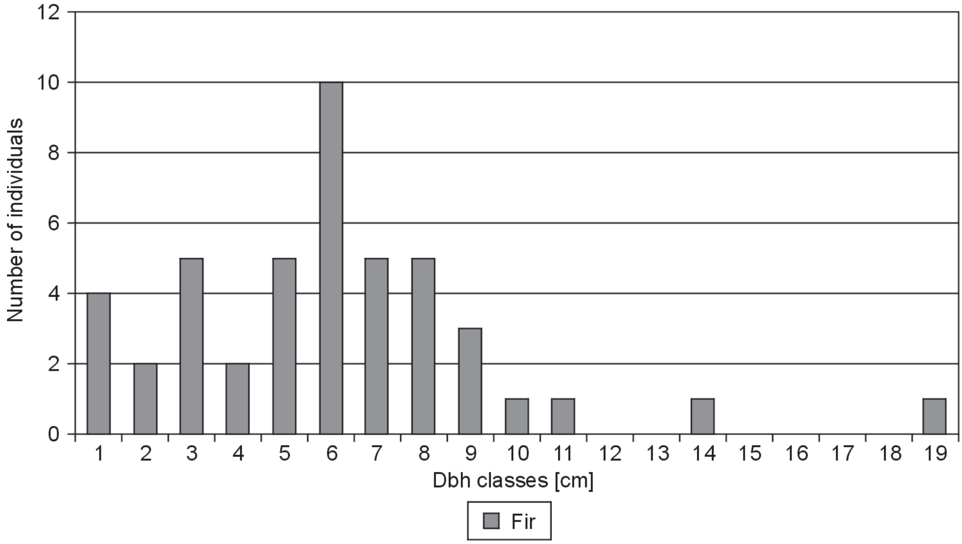

Fig. 8. The diameter distribution of fir trees in the forest stands of the *Abietetum albae* association in five-centimetre ranges (including the incomplete range 8—9 cm)

Explanations: **1** — 8—9, **2** — 10—14, **3** — 15—19, **4** — 20—24, **5** — 25—29, **6** — 30—34, **7** — 35—39, **8** — 40—44, **9** — 45—49, **10** — 50—54, **11** — 55—59, **12** — 60—64, **13** — 65—69, **14** — 70—74, **15** — 75—79, **16** — 80—84, **17** — 85—89, **18** — 90—94, **19** — 95—99

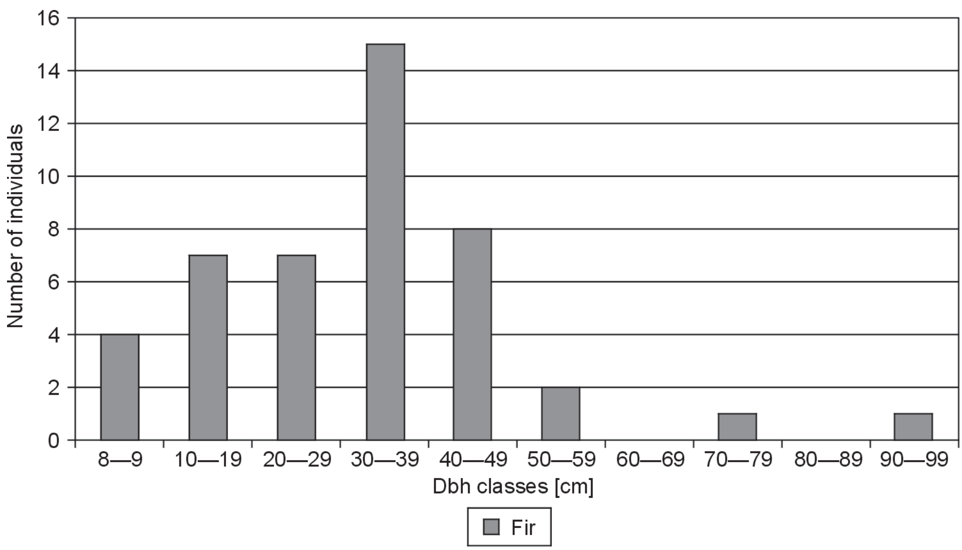

Fig. 9. The diameter distribution of fir trees in the forest stands of the *Abietetum albae* in the ten-centimetre ranges (including the incomplete range of 8—9 cm)

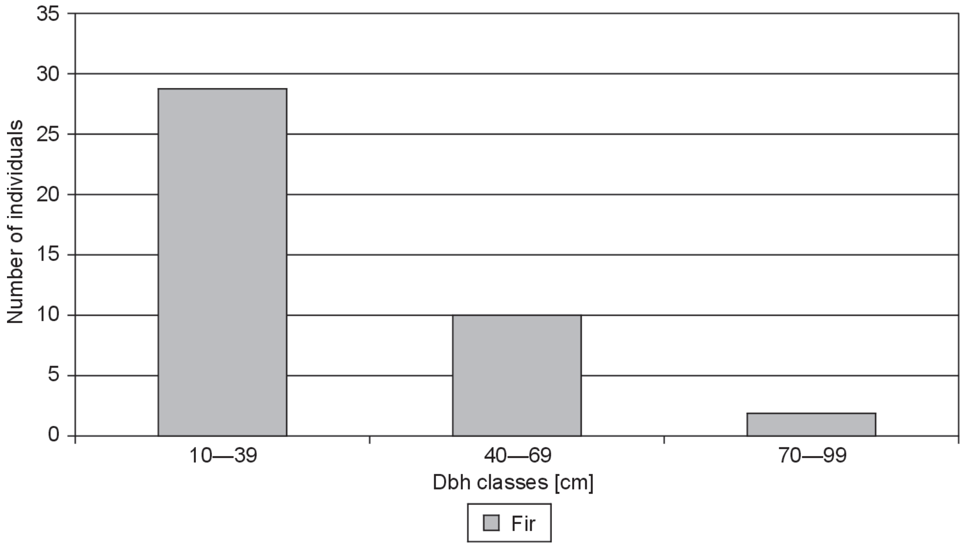

Fig. 10. Number of fir trees in the forest stands of the *Abietetum albae* association in the three categories of diameters (low, mean and high)

Table 11. Mean values of fir tree diameters for the particular permanent study plots in the central part of the Cracow-Częstochowa Upland

Location	Goncerzyca		Hucisko		Trzyciąż	
Permanent study plot	I	II	III	IV	V	VI
Mean diameter for the plot [cm]	30.1	22.5	29	27.3	48.6	54
Mean diameter for the locality [cm]	26.3		28.1		51.3	
Mean diameter for all I—VI in the C-CzU [cm]	35.2					

Abbreviation: **C-CzU** — the Cracow-Częstochowa Upland

Goncerzyca II. The lowest differentiation of diameter values occurred in Hucisko (plot no. IV), because 8 of the 11 individuals in that forest stand represented neighbouring, low diameter classes (25—29 cm and 30—34 cm). In the case of study plot no. V from Trzyciąż, its high mean diameter was the result of the presence of a few specimens with mean diameters that were larger than 40 cm, as well as specimens with large (larger than 70 cm) diameter classes. The thickest fir stand grew on the VI permanent study plot in Trzyciąż. The presence of a single tree with a diameter at the upper edge of the diameter scale in the highest diameter range (close to the dimensions of a natural monument) was crucial in relation to the high value of the mean diameter on plot VI (Fig. 11). The mean value for the forest stands on study plots I—VI amounted to approximately 35 cm and included a range of values from 22.5 to 54 cm.

Symmetry of fir tree trunks. Measurements of the diameters of fir trees were done in two main directions — N—S and E—W. These revealed that the fir trees

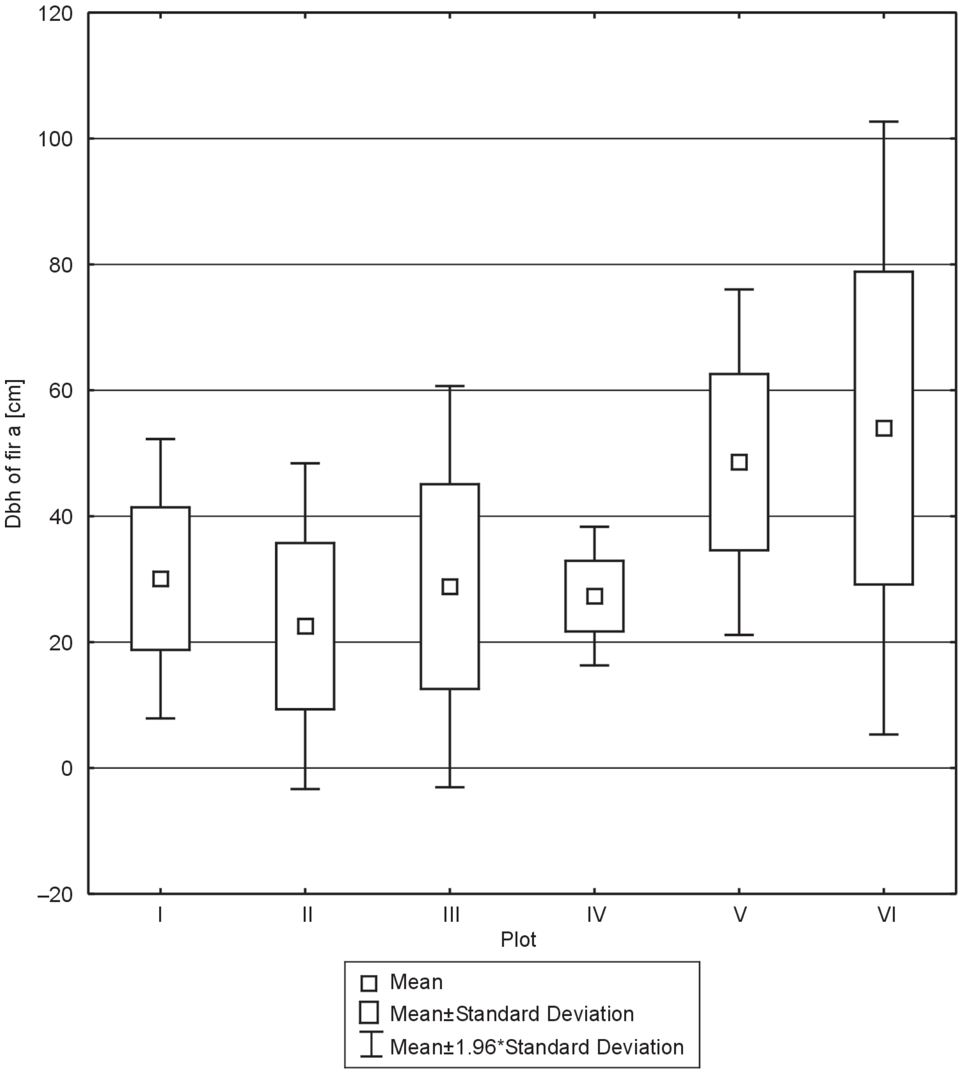

Fig. 11. Differentiation of the mean diameter (dbh) of fir trees in the forest stand layer (a) on the study plots I—VI in the phytocoenoses of the *Abietetum albae*

in the analysed forest stands had irregular shapes of tree trunks in relation to these directions in the majority of cases. The relationships between regularly (R) and irregularly (IR) shaped tree trunks on permanent study plots I—VI were expressed by a ratio R : IR of 1 : 1.64. It must be stressed that four thicker individuals that were more than 50 cm in diameter had an influence on the result. These were measured at 1.3 m but in the circumference, not in the diameter. Therefore, in agreement with methodology applied in this elaboration, their trunks were counted into those that had developed regularly and thus influenced the ratio.

Admixtures in the forest stand did not have larger diameters and did not compete with the fir stands in the majority of cases. Rowan, which occurred in the highest numbers (i.e., 12 individuals/12 ares), was the most important admixture species in the stand. Rowan dominated in the lowest diameter classes: on plot no. III — the mean value of its diameter was 14.5 cm, on plot V — 11 cm and on plot VI — 9 cm (Fig. 12). *Sorbus aucuparia* is a tree that is not naturally a competitor to the main forest stand (in the managed forest for the so-called "final stand"). It fulfils a very important biocoenotic role as a succession or regeneration starter species.

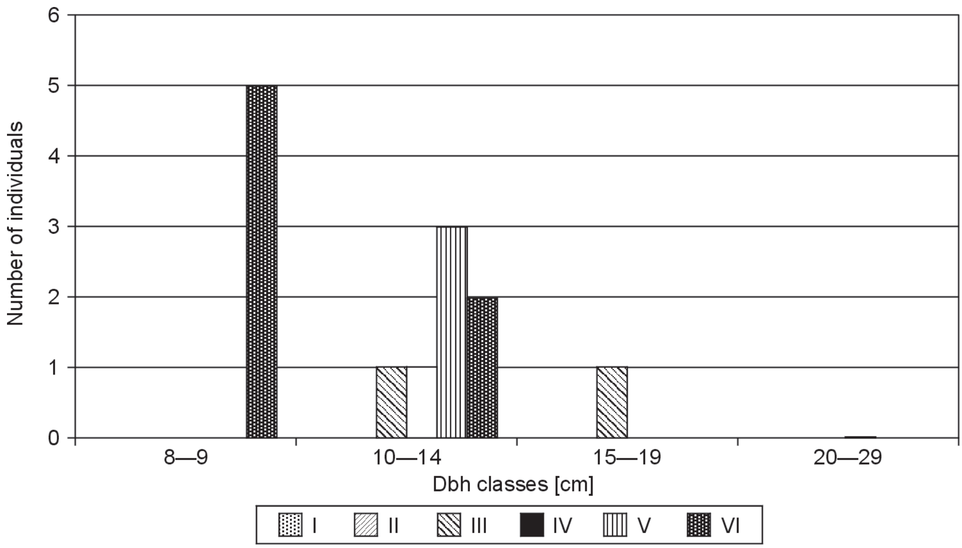

Fig. 12. Diameter (dbh) distribution of rowan in the tree layer (a) of the *Abietetum albae* association (including the incomplete range of 8—9 cm) on study plots I—VI

Beech, which occurred as three trees, also did not reach significant dimensions in diameter (on plot no. I — 33.5 cm, on plot no. IV — 18.5 cm and 11 cm (mean 14.5 cm in diameter) in the *Abietetum albae* association. Similarly, trees that grew singly: pine (plot II — 31.5 cm), sycamore (plot III — 16 cm) or birch (plot III — 34 cm) also had small diameters at breast height. The earlier-mentioned hawthorn individual, which occurred in the a_2 sublayer (lower level of the forest stand), was only insignificantly thicker than eight centimetres. Then, all admixtures were included in both the incomplete range 8—9 cm or, at least, in a low class of diameters (10—39 cm) and were not fir competitors.

Fir was the most important species that formed the stand on the permanent study plots (I—VI) of the *Abietetum albae* association from the central part of the Cracow-Częstochowa Upland.

4.4. Diameter and height structure of the up-growths

Fir up-growths were specimens that reached a diameter of 0.1 to 7.99 cm and a height of 0.5—7.99 m. These were found on four (I—IV) from the six study plots. In total 23 young specimens of *Abies alba* that were included into that category occurred on 12 ares.

The diameter structure. The highest number of fir up-growths that occurred on plots I—IV had diameters of more than three up to four centimetres (eight specimens). The highest number of up-growths with dimensions that were included in that range grew in plot no. III in Hucisko. On the other hand, up-growths had the largest diameters (6.1—7 cm) on two plots (Goncerzyca II and Hucisko III); on these plots (II and III) up-growths of *Abies alba* reached the widest spectra of diameters (Fig. 13).

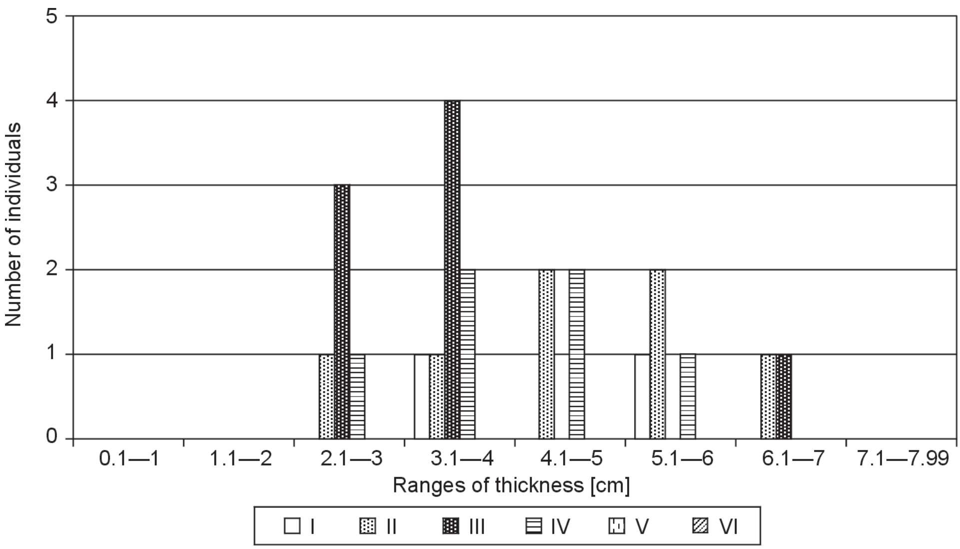

Fig. 13. Differentiation of the values of fir tree diameters in the up-growths on permanent study plots I—VI

Fir up-growths reached the highest mean value of the diameter at breast height on study plot no. I (Goncerzyca), and the lowest value on study plot no. III (Hucisko). The results of subtracting the mean values on Goncerzyca I and II is lower than the results of subtracting the mean values in Hucisko III and IV (Fig. 14).

The height structure. The highest number of *Abies alba* individuals was aggregated at a height of more than two up to five metres on the permanent plots on which fir up-growths grew (I—IV). On all of these plots (I—IV) fir

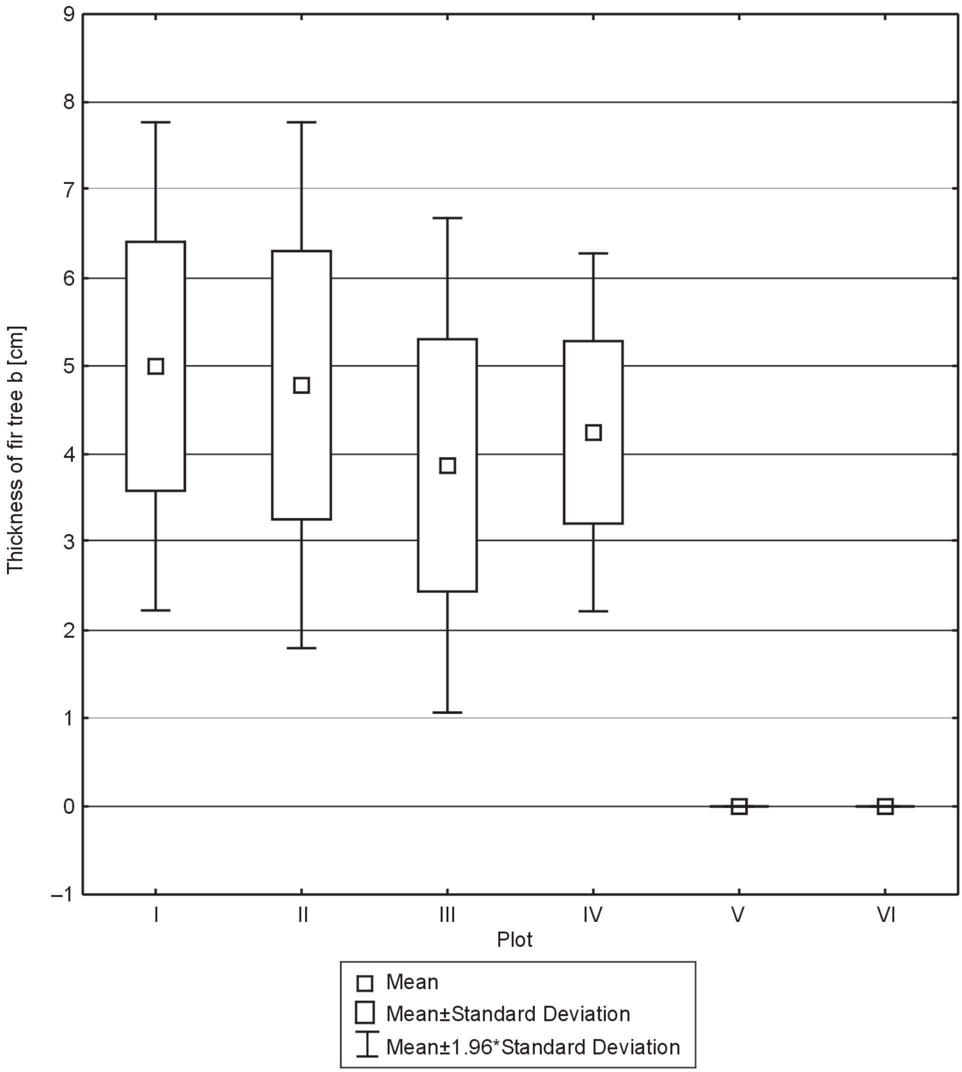

Fig. 14. Differentiation of the mean values of the fir tree diameters in the up-growths on permanent study plots I—VI

up-growths were represented in a height range of between 2.1—3 m. Up-growths on study plots no. II (Goncerzyca) and III (Hucisko) reached a wide spectrum of height. However, the highest up-growths, which reached a maximum height of six metres were on permanent plots no. III and IV in Hucisko. The share of *Abies alba* in higher height classes seems promising. The lower sublevel of a forest stand (a_2) is gradually enforced with young fir trees in this way (Fig. 15).

The mean values of the heights were quite similar to each other not only within the pairs of plots I—II and III—IV, but also between the locations. More-

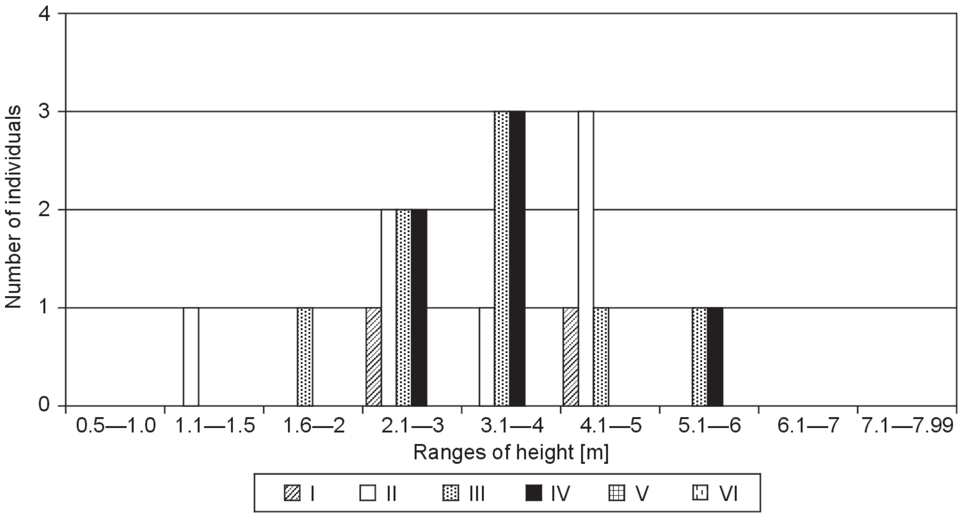

Fig. 15. Differentiation of the heights of the fir up-growths on study plots (I—VI) in particular height classes

over, they had a similar range of values (Fig. 16). This might be evidence that on all plots that were analysed (I—IV) fir up-growths are in a similar age class. However, such a conclusion in that place would not be feasible. The significant shadow-tolerance of fir, which allows it to live in a state of a lower growth rate for many years and even many decades, is one of the specific characteristic features of this species. Therefore, firs can live under a mature forest stand waiting for a canopy opening and during that time, using even a single-tree gap, can meet their chance for vertical growth.

Rowan up-growths form the most numerous group among the up-growths on permanent study plots I—VI (46 specimens/12 ares). The share of rowan up-growths in the diameter and height structure of all up-growths was differentiated on particular study plots. The highest number of rowan up-growths had the lowest range of diameters: from 0.1 to 1 cm (13 specimens, somewhat more than 28%) simultaneously. Young rowans were aggregated on plot no. II (Goncerzyca). In addition to them, small specimens that had such small diameters also occurred on plot no. V in Trzyciąż. On plot V rowan up-growths occupied almost all of the spectra of diameters with the exception of the highest range (7.1—7.99 cm). Rowans on permanent plot no. VI were found in a somewhat narrower range of diameters (with the exception of the first and the last range). Up-growths of that species occurred only as single individuals and did not exceed a diameter of four centimetres in Hucisko (III and IV). Rowan up-growths did not grow on plot no. I (Fig. 17).

Significant differentiation in relation to the mean values of the diameters that were reached by young specimens of *Sorbus aucuparia* was noticeable on

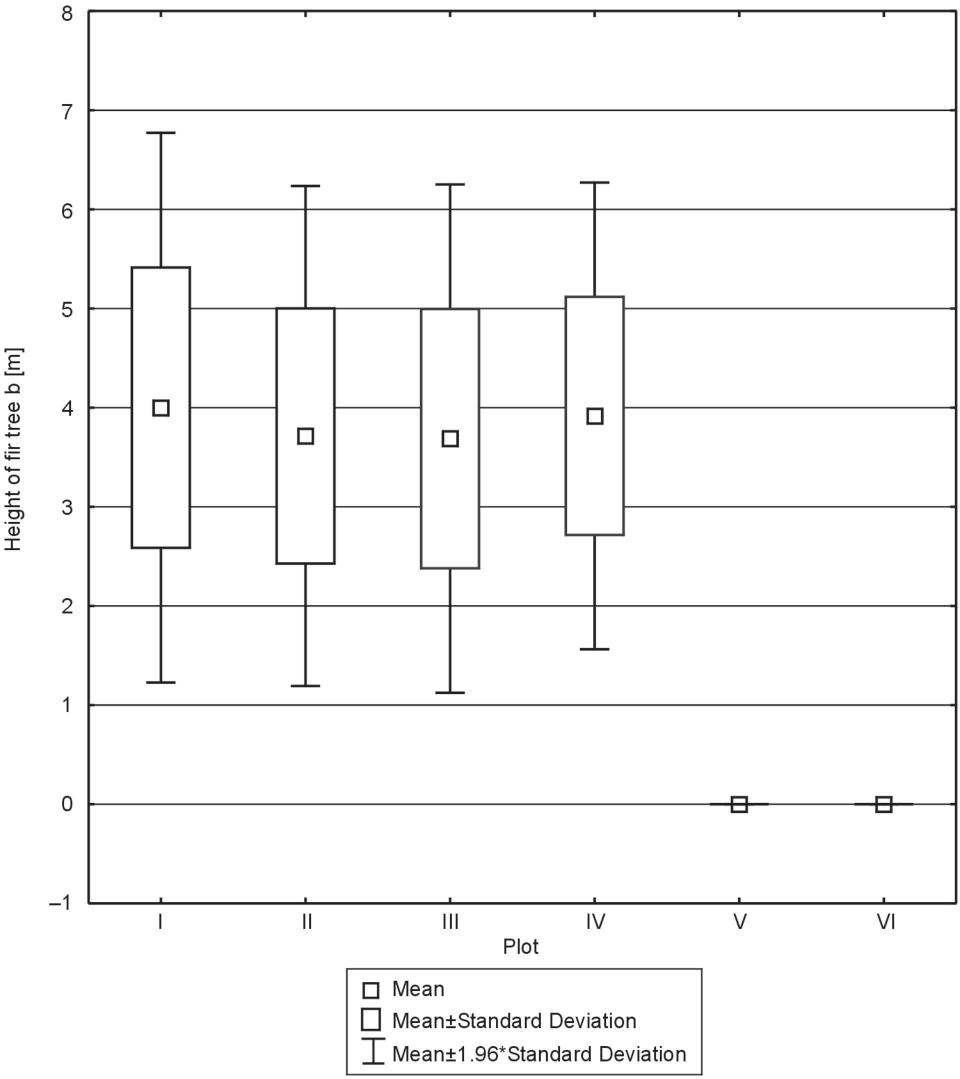

Fig. 16. Differentiation of the mean heights of fir up-growths on permanent study plots I—VI

study plots II, V, and VI on which rowan up-growths occurred more abundantly. Rowans from Goncerzyca II had lowest mean diameter and simultaneously the lowest differentiation in relation to this feature. Rowans from study plot no. VI in Trzyciąż reached the highest mean diameter. The trunks of rowans from plot no. V in Trzyciąż had highest differentiation in relation to the diameter at breast height (Fig. 18).

Study plot Goncerzyca II, where the highest number of the smallest rowans was found, as well as plots V and VI, where rowan up-growths reached the widest spectrum of heights, or the highest values of height were most distinguished

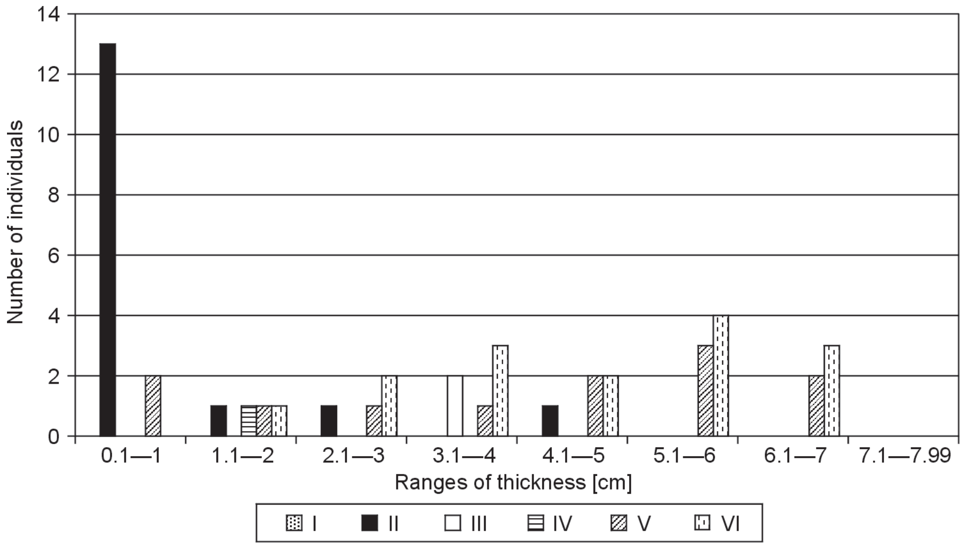

Fig. 17. Diameter differentiation of the rowan up-growths on study plots I—VI

study plots taking under consideration the differentiation the heights of rowan up-growths. None of the study plots had young rowans within the height range of between 1.6 and 2 m. The general conclusion is that the greatest number of rowans had the lowest height in the zone of 0.5—1 m (28%). It is worth paying attention to the zone from 4 to 7 m, which is on study plots I—VI composed of approximately 46% of rowan up-growths (Fig. 19).

The height differentiation of rowan up-growths on study plots I—VI (Fig. 20) had a similar arrangement as in the case of the mean diameters (the lowest mean height of up-growths in Goncerzyca II, the lowest in Trzyciąż VI, and transitive in Trzyciąż V).

Spatial relationships between fir and rowan in the shrub layer. Based on the data collected, it can be observed that rowan appeared numerously in places where fir was absent (Fig. 16 and 20) and that these species replace one another in space. The exception to that rule was plot no. II on Goncerzyca Rock where both species coexisted in the shrub layer. Therefore, the assumption must be made that in conditions of that plot both species replace themselves in altitudinal zones in the forest shrub layer. Rowan is a light-demanding species and it belongs to a succession and regeneration starting species. It has little chance of survival under fir up-growths, which are usually significantly taller than rowan. The only chance for any further development of rowans are plots where fir is absent (V and VI). Rowan occurred there in greater numbers when they exceeded two metres in height.

Birch, hazel, beech, and sycamore up-growths did not occur on permanent plot no. I (on Goncerzyca Rock). The above-mentioned up-growths did

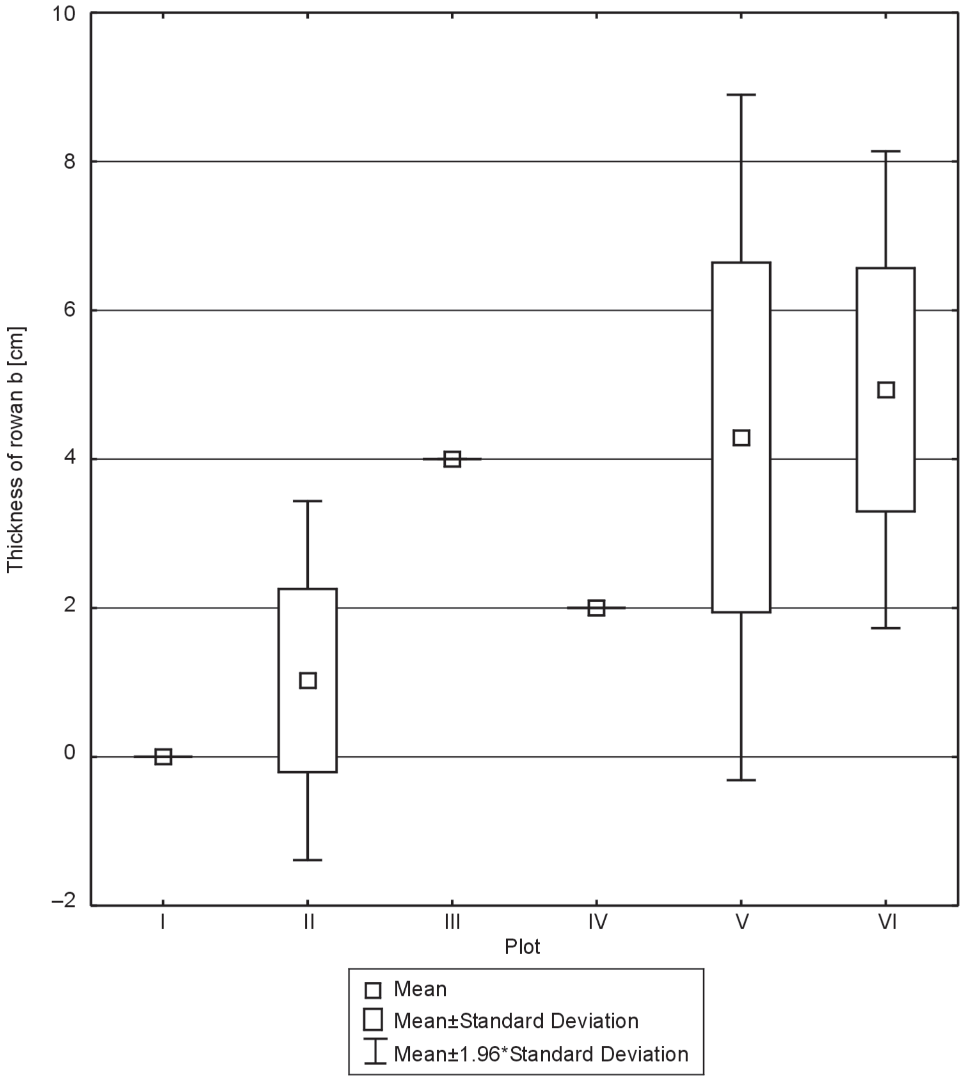

Fig. 18. Differentiation of the mean diameter values of rowan up-growths on study plots I—VI

not exceed a diameter of five centimetres on any of the other permanent study plots (II—VI). All (100%) birch up-growths and a significant majority of sycamore up-growths (73%) were in the lowest class of diameters, which included the values from 0.1 to 1 cm, respectively, on study plots no. V in Trzyciąż and number III in Hucisko. On the other hand, young hazels with diameters that ranged from 3 to 4 cm dominated plot no. IV in Hucisko. Beeches that had the widest spectrum of diameters from among the species that were analysed occurred most numerously (82%) in the range of diameters from 0.1 to 1 cm. The

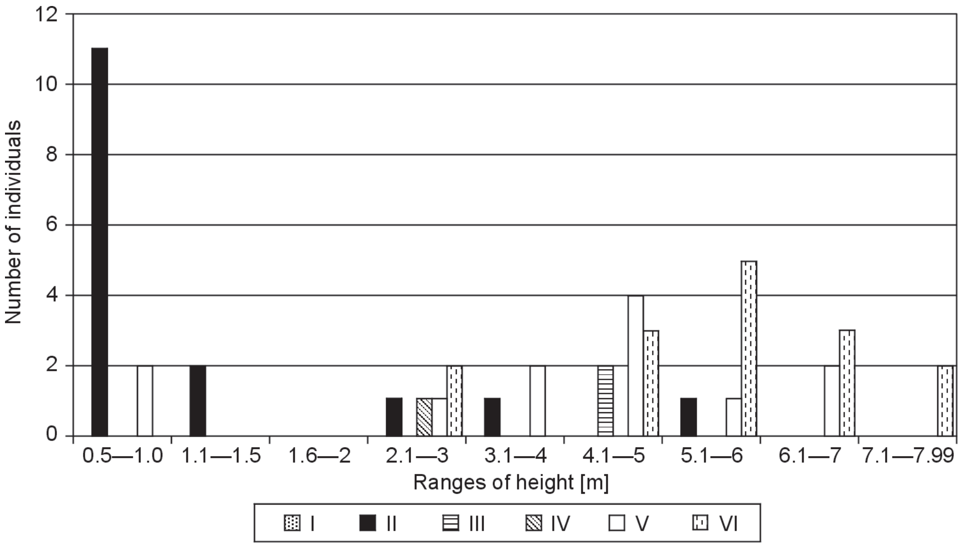

Fig. 19. Height differentiation of rowan up-growths on study plots I—VI

up-growth of this species reached the highest possible range of diameters from more than 4 to 5 cm.

None of study plots II—VI had birch, hazel, beech, or sycamore up-growths taller than five metres in height. Birch and hazel up-growths were numerous on study plot no. V in Trzyciąż (there was the lack of fir up-growths, but rowan occurred abundantly); however, these were aggregated in various altitudinal zones of the forest layer. Young birches were mainly in the height range of 0.5 to 1 m and hazels were in the height range of 4.1—5 m. Beeches and sycamores had quite a wide height spectrum; beeches were in zones 0.5—3 m and 4.1 to 5 m, while for sycamores the zone included all of the possible height ranges from 0.5 to 5 m. Beech was the constant component in the majority of the permanent plots, whereas sycamore was the dominant species in the shrub layer on plot no. III in Hucisko.

Other species in the shrub layer (e.g., aspen, hornbeam, and alder buckthorn up-growths) did not have any significant importance for the diameter-height structure. These occurred sporadically (one or two observations/12 ares) and did not exceed 0.5 cm in diameter and a height of one metre with one exception.

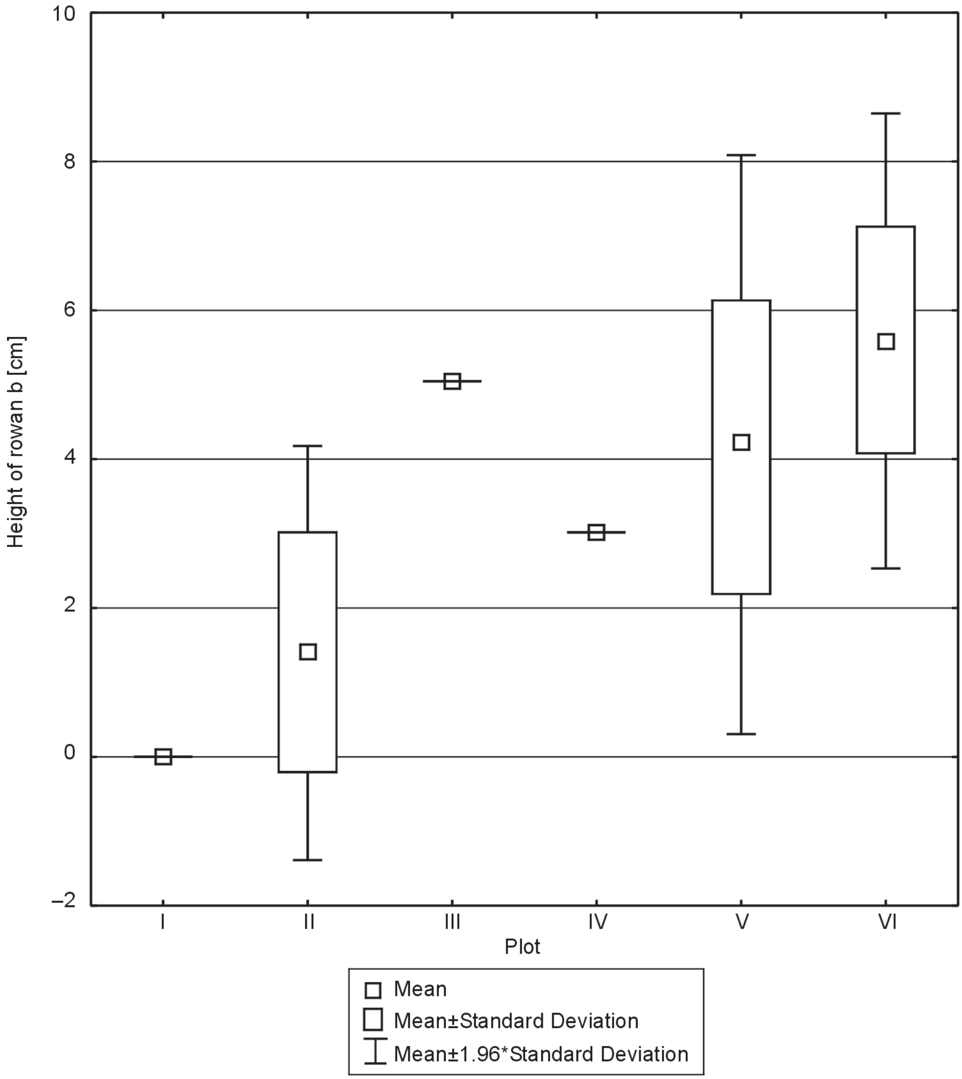

Fig. 20. Differentiation of the mean values of rowan height in the up-growths on permanent study plots I—VI

4.5. Fir in the new-growths

Fir new-growths in the presented studies included both the categories of seedlings and young specimens of fir that did not reach a height of 0.5 m. In total, 829 *Abies alba* individuals occurred, comprising the new-growths (on average there were 34 individuals/m^2 in an area of 24 m^2, that is, 24 squares distributed regularly as four 1 m × 1 m squares (A, B, C, D) within the inner subarea "i" of each of the six permanent study plots (I—VI). From among 829 specimens, 283 (34%) had cotyledons, and therefore those were still in the stage of seedlings and their numbers in particular squares varied between 1 and 48 individuals/m^2. The particular study units used in the studies on the new-growths were differentiated in relation to the mean density of fir seedlings from 4.5 individuals/m^2 (Goncerzyca I and Hucisko III) through 4.7 individuals/m^2 (Trzyciąż V) and 6.2 individuals/m^2 (Hucisko IV), up to 16.2 individuals/m^2 (Trzyciąż VI) and a maximum of 34.5 individuals/m^2 (Goncerzyca II); the average was 12 individuals/m^2 in the seedling stage. However, the seedlings and older new-growths were not differentiated but were regarded as one category — fir new-growths.

Height structure of fir new-growths on permanent study plots I—VI. The greatest differentiation of the heights of fir new-growths occurred on plot no. II in Goncerzyca. Such a differentiation proved the potential possibilities for the further development of new-growths and their gradual transition to higher sublevels and levels of an upland mixed coniferous fir forest *Abietetum albae*. The species on the study plot no. I had highest mean value of the height of new--growths (more than eight centimetres), while on plot no. III in Hucisko they had the lowest mean value. The lowest differentiation of the height of new-growths was recorded on study plot no. IV in Hucisko (Fig. 21).

The height structure of fir new-growths in the study units. Among 24 squares (1 m × 1 m), fir new-growths that had a mean height higher than eight cm were only observed in four; in 13 squares the new-growths of fir had/reached from 6 to 8 cm on average, while in seven squares they ranged from 2 to 6 cm (Fig. 22).

Fir new-growths on Goncerzyca I and II had the highest mean values of height in the 1 m × 1 m squares that were studied. The heights of fir trees from squares 2A (the maximum differentiation of values included a range heights from 2 to 19 cm) had the highest mean values of fir heights, as did 1D and 1B in the sequence of lowering mean values. Moreover, square 3D, which had a mean value of approximately two centimetres, had the largest influence on a low value of the mean height of fir new-growths on study plot no. III in Hucisko, where the other squares had new-growths that were approximately five centimetres high. Study plots no. IV in Hucisko, as well as numbers V and VI from Trzyciąż revealed quite equal values of mean heights among new-growths, despite the fact that these values were significantly changeable in particular squares.

The heights of fir new-growths and the percentage of cover of the herb and moss layers. On five of the six permanent study plots (Fig. 23), the fir new-growths reached an average height of 5.9—8.3 cm in the herb layer, which covered a percentage range of 40—50%. However, over 60% of the cover of the herb layer was connected with the lowest mean value of heights that were reached by fir new-growths (5.1 cm on average).

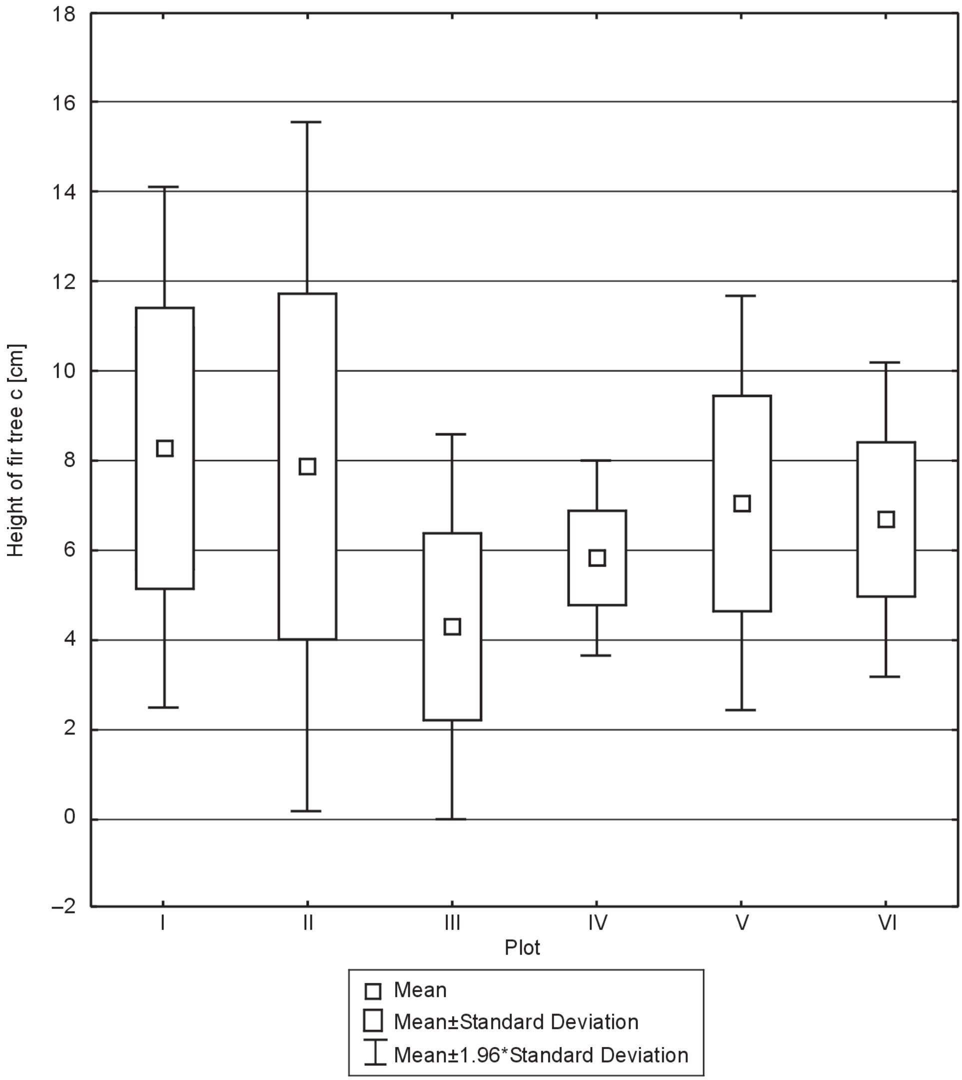

Fig. 21. Differentiation of mean values of height of fir new-growths on study plots I—VI

The correlation analysis between the height of the fir new-growths and the covering of a particular species of vascular plants that created the herb layer did not reveal any statistically significant relationships in the majority of cases. In only two cases of the following species: *Oxalis acetosella* (r = –0.52) and *Acer pseudoplatanus* (r = –0.58) did the correlation coefficients reach a statistically significant value.

The relationships between the cover of the moss layer and the height of fir new-growths did not reveal any clear tendency. The highest values of the percentage cover of the moss layer were related to tall (but not the tallest), that is,

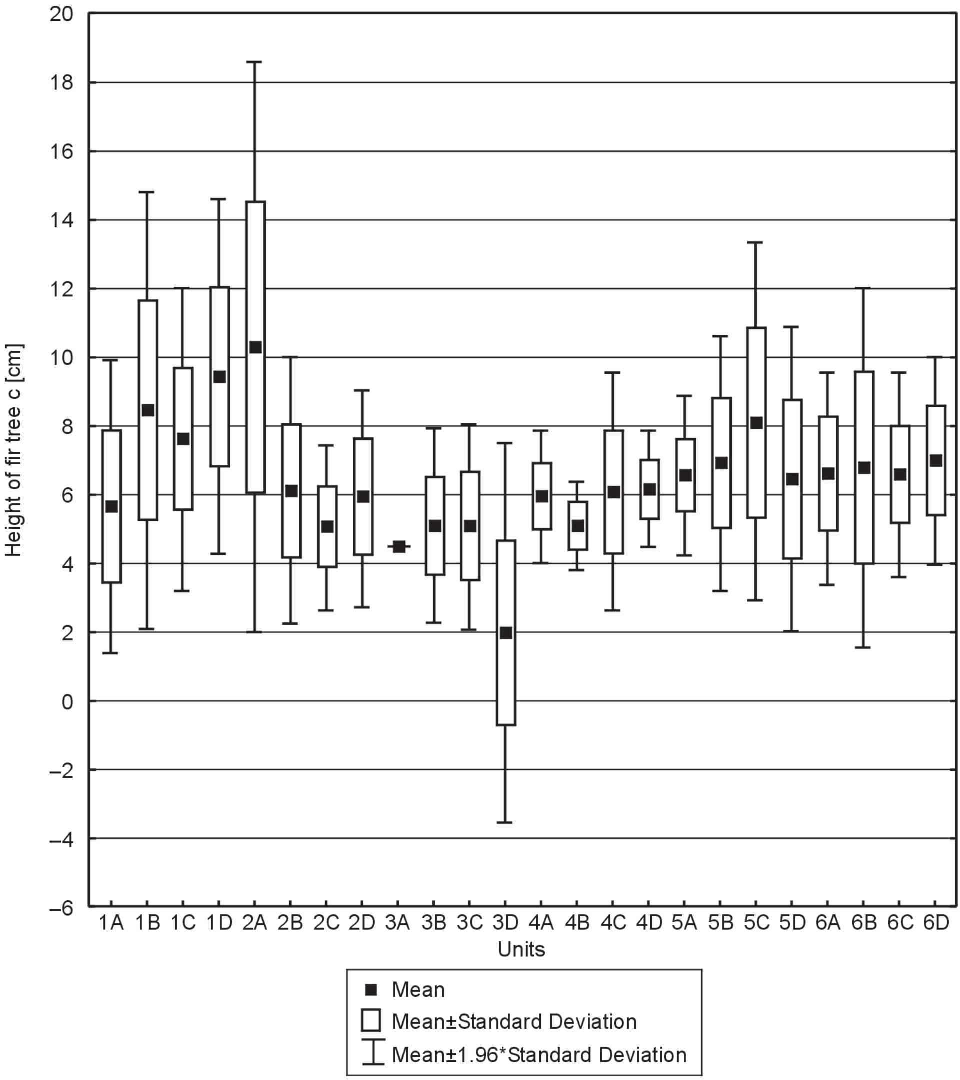

Fig. 22. Differentiation of the mean values of the heights of the fir new-growths in the study units (24×1 m^2 squares in total); units: 1A—D — Goncerzyca I; 2A—D — Goncerzyca II; 3A—D — Hucisko III; 4A—D — Hucisko IV; 5A—D — Trzyciąż V; 6A—D — Trzyciąż VI

7.1 and 7.9 cm new-growths. The average value of the cover of the moss layer in one case was connected with a minimum height of fir new-growths (the mean was 5.1 cm) whereas in the second case — with new-growths that were somewhat taller (the mean was 6.8 cm). An interesting fact is that the lack of a moss layer did not promote the growth of fir new-growths (the mean amounted to only 5.9 cm), whereas a share of mosses close to 10% was connected with the tallest new-growths (the mean value was 8.3 cm).

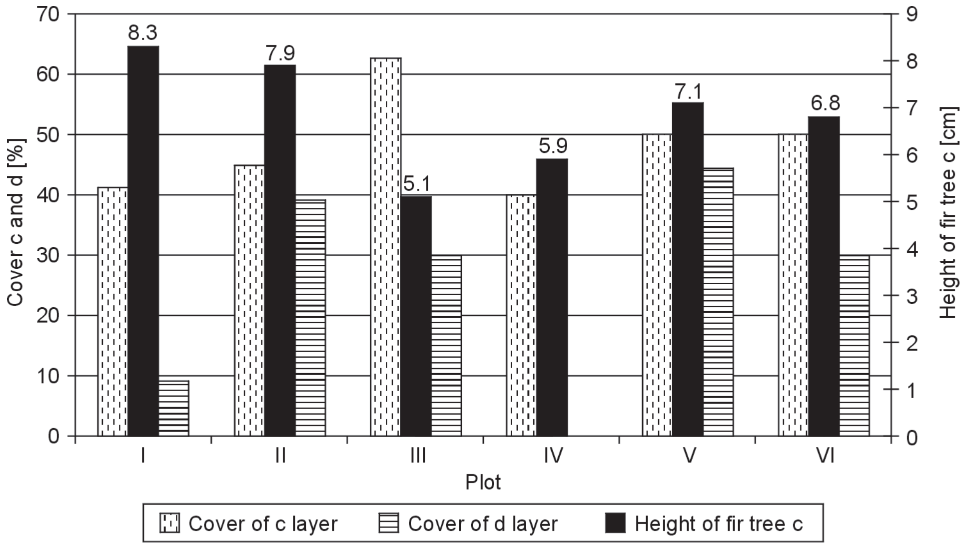

Fig. 23. Cover of the herb (c) and the moss (d) layers versus height of fir new-growths on study plots I—VI

Percentage cover of fir and the herb and moss layers. The maximum values of the fir cover on the study plots were connected with a herb layer cover below the level of 45% in Goncerzyca (permanent study plots no. I and II). On the other hand, the minimum value of the fir new-growth cover was connected with a maximum percentage cover of the herb layer in Hucisko III (Fig. 24).

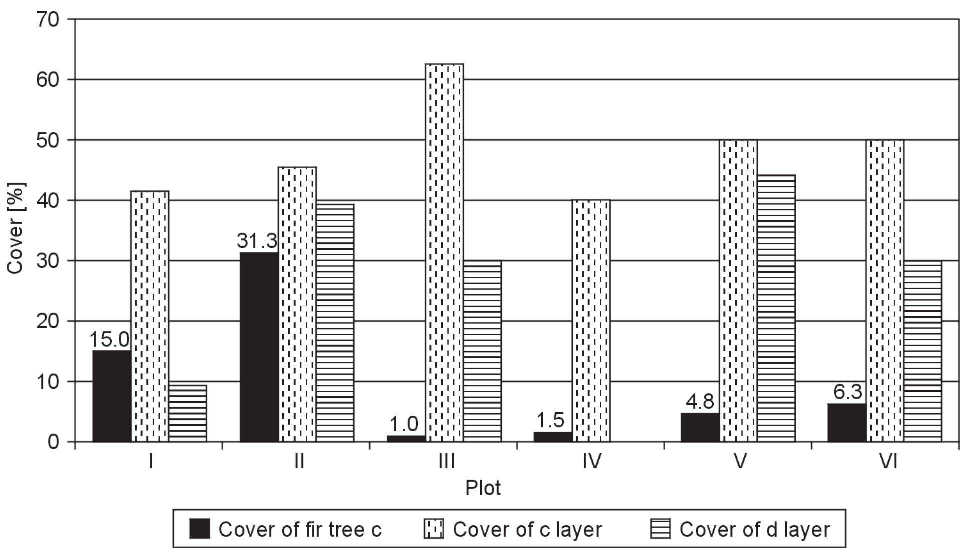

Fig. 24. Cover of fir trees in new-growth (c) versus herb (c) and moss (d) layers

Despite a barely noticeable relationship between the density of the plants in the herb layer, expressed as a percentage of cover, and the fir share in that layer of the forest, the correlation analysis revealed a statistically significant, positive but weak, correlation between these two variables at the level of r = 0.42.

Based on the relationships between the cover of young firs and the cover of the moss layer, it was not possible to fix any regularity because the maximum percentage cover of fir trees in the new-growths was connected with both a medium (below 40%) and a minimum (below 10%) cover of the moss layer.

Species of the herb layer which were not favourable for fir regeneration. As was mentioned earlier, in the developmental stage of new-growths on all of the study plots, although not in all of the squares, fir was always accompanied by only three taxa of vascular plants that built the herb layer: *Athyrium filix-femina*, *Oxalis acetosella*, and *Rubus hirtus et pedemontanus*. All of these species, on each study plot from the three main localities (Strzegowa Poduchowne, Hucisko, and Trzyciąż) represent various types of interdependence (Fig. 25). However, the

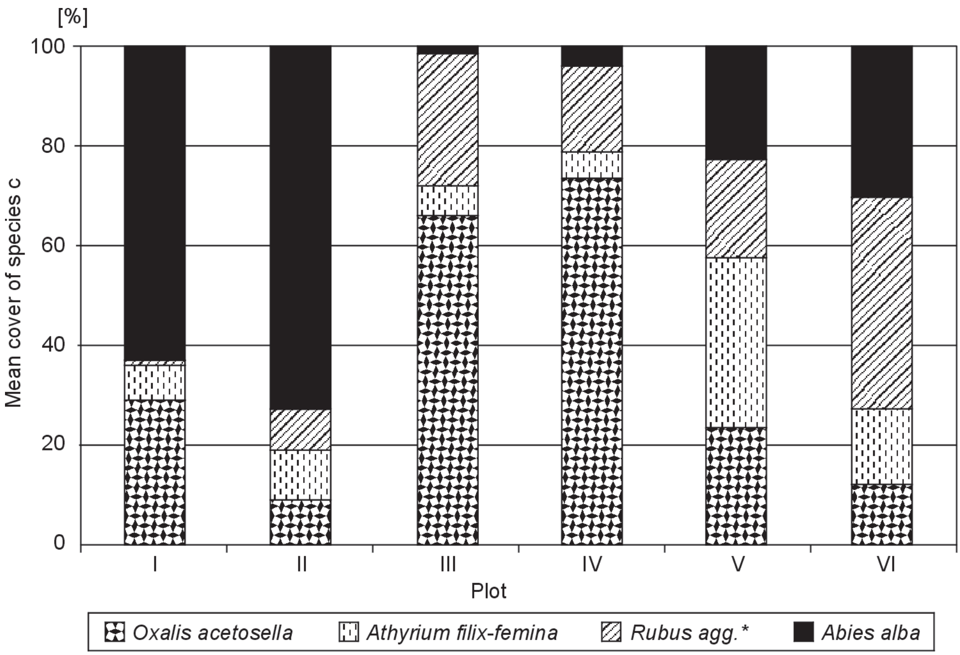

Fig. 25. Interdependences between the cover of fir in the new-growths and the species of vascular plants that constantly accompanied them (*Rubus agg.** — *Rubus hirtus et pedemontanus*)

pattern that was characteristic for the given type of the locality was maintained. The numbers of the above-mentioned species were similar in the main locality, but varied significantly between localities. This was particularly visible in the case of the fir trees (Fig. 26).

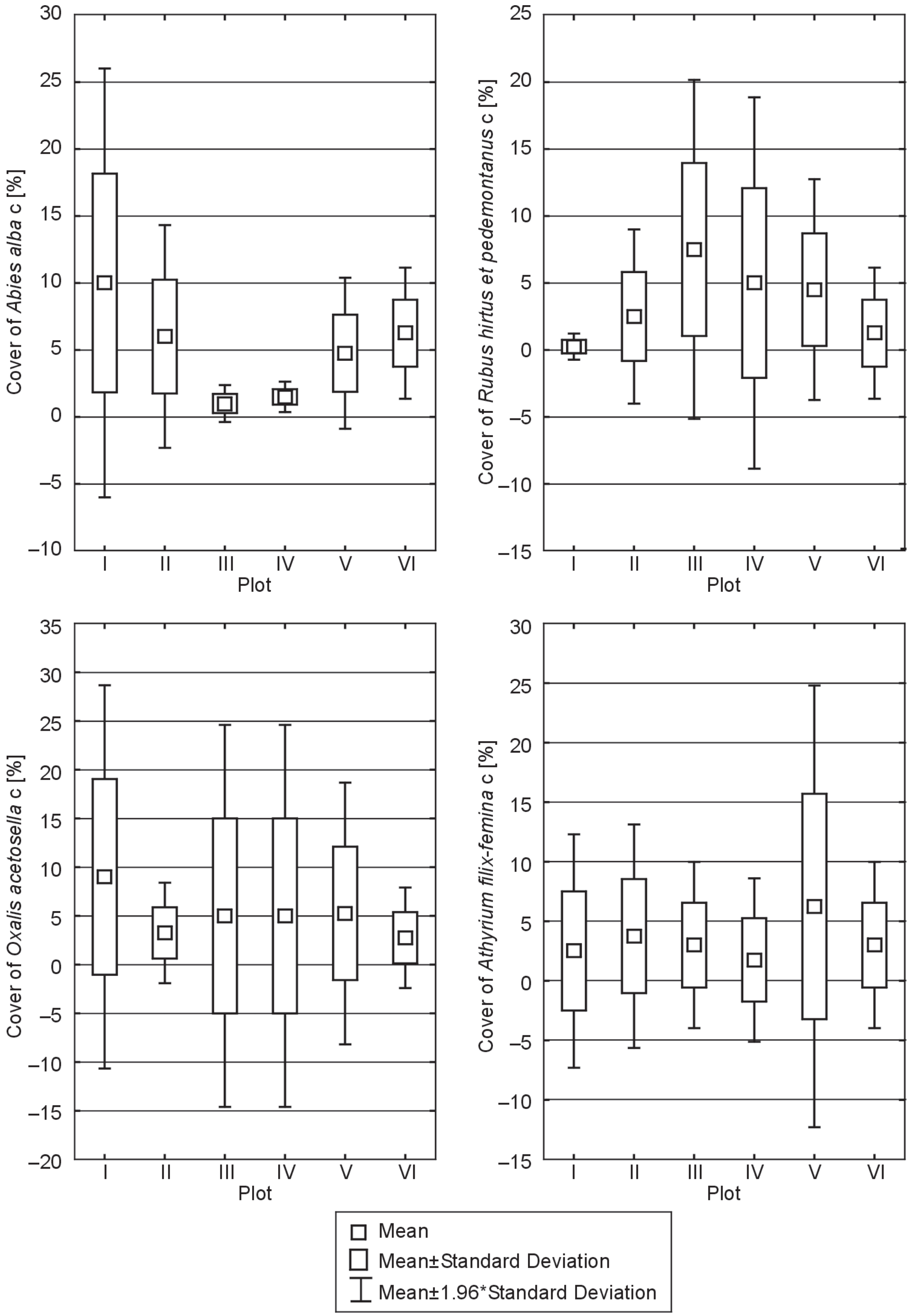

Fig. 26. Differentiation of the mean cover of fir *Abies alba* and individuals of *Rubus hirtus et pedemontanus*, *Oxalis acetosella*, and *Athyrium filix-femina* on study plots I—VI

It was observed that *Rubus hirtus et pedemontanus* and *Oxalis acetosella* were distinctly unfavourable species for fir regeneration in the herb layer (c), based on the results of the correlation analysis. Both taxa had a significant statistically high negative correlation with the cover of the *Abies alba* in new-growths. The values of the correlation coefficients in that case amounted to r = –0.9 and r = –0.8 respectively (Fig. 26, Table 12).

Table 12. Correlation coefficients between *Abies alba* cover and constant herb layer species

Species \ Coefficients	Mean	Standard Deviation	*Oxalis acetosella*	*Athyrium filix-femina*	*Rubus hirtus et pedemontanus*	*Abies alba*
Oxalis acetosella	15,85714	18,61387	1,000000	–0,328643	0,689989	**–0,768778***
Athyrium filix-femina	8,85714	5,39841	–0,328643	1,000000	–0,396517	0,334972
Rubus hirtus et pedemontanus	5,57143	5,09435	0,689989	–0,396517	1,000000	**–0,900972***
Abies alba	6,07143	3,87759	**–0,768778***	0,334972	**–0,900972***	1,000000

Explanations: * — statistically significant correlations

The third species that coexisted with fir that was analysed — *Athyrium filix-femina* — did not have any distinct interactions with *Abies alba*. Both the highest and the lowest mean values of the fir cover had average (quite equal) values of the cover of that abundantly growing fern. Additionally, the highest cover of the fern did not drastically reduce the cover of the fir. Therefore, as in the presented studies, the *Athyrium filix-femina* cannot be acknowledged as a species that is univocally unfavourable for the regeneration of young firs.

Ferns are acknowledged as plants that are strongly competitive to new--growths and up-growths of tree species. Taking this under consideration, a correlation analysis was made also between the cover of fir new-growths and the total cover of all of the fern species (*Dryopteris carthusiana*, *D. dilatata*, *D. filix-mas*) that were present on particular permanent plots. The correlation coefficient amounted to only a value of r = 0.03, and thus it was not statistically significant. This once again indicated that there is lack of competition between other species of ferns in relation to fir new-growths. At the same time, this confirmed the already known data related to the distinct and strong shadow-tolerance of *Abies alba* in its juvenile period of life and in its early youth.

Types of herb layer and fir new-growths. The following types of herb layer were distinguished, based on the list and cover of all vascular species in the herb layer that were done in 24 squares of an area 1 m^2 each:

— Dom — a herb layer containing the dominant species;
— CoD — a herb layer containing two or three codominants;
— NoD — a herb layer without a distinct dominance or with equal shares of many species.

The mean height of fir new-growths was tallest in places where the fir was a dominant species, as was revealed by the analysis of the data gathered. This means that the fir competed with other species of the herb layer or grew above their level to the point at which these species were not competitors to fir. The differentiation of the values of fir heights was the largest in such cases. It is understandable that inner competition between specimens of the same species is stronger than interspecies competition. Moreover, fir can vegetate in a state of very slow growth for a relatively long period of time because of its distinctive feature of shadow tolerance. This complicated the issue of the relationships between individuals of vascular plants in the herb layer (Fig. 27).

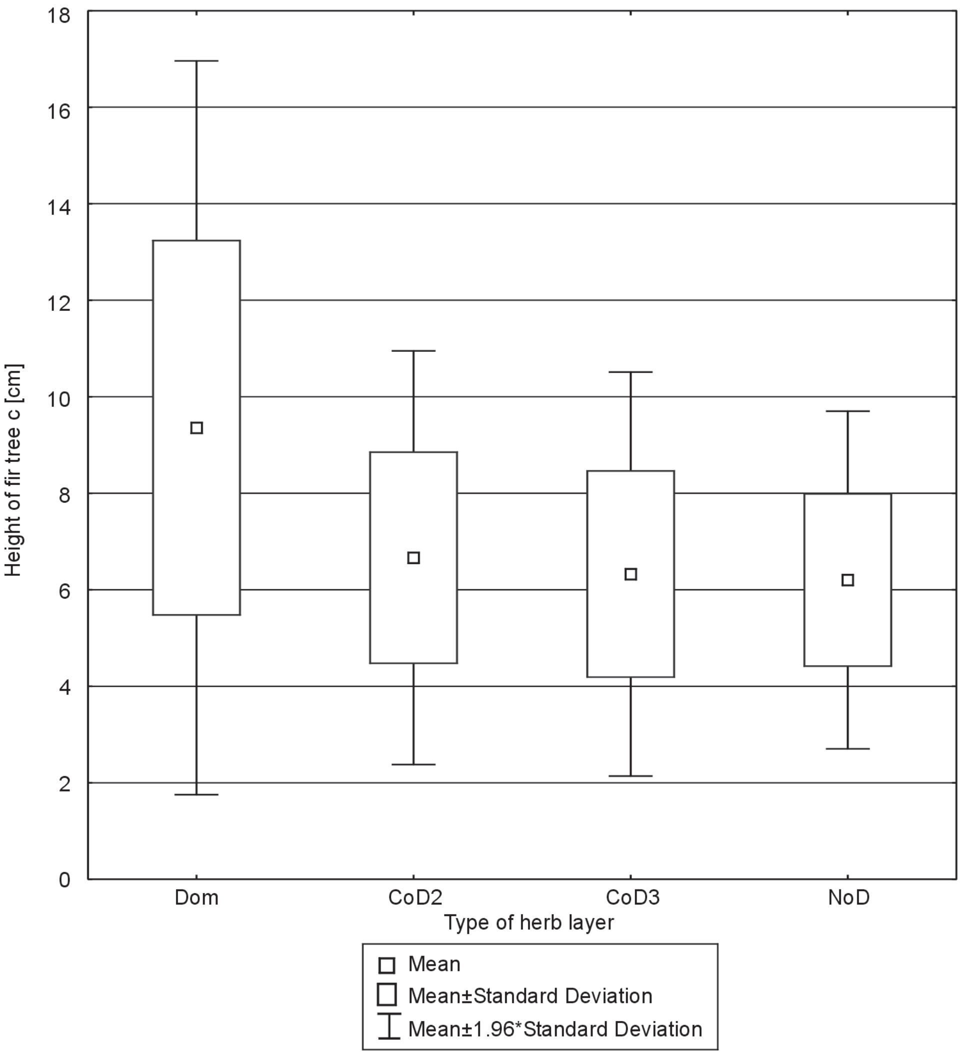

Fig. 27. Height differentiation of fir new-growths in particular types of the herb layer (c)
Explanations: Dom — fir as dominant species in c; CoD2 — two dominants in c; CoD3 — three dominants in c; NoD — none dominant in c

It can be seen that the more diversified the herb layer is in species (out of distinctive dominants), the lower the mean height of firs is, and simultaneously the less the fir differentiation is (this tendency is barely noticeable).

The percentage cover of fir new-growths is also highest in places where fir fulfils the role of the dominant in the herb layer. For a healthy regeneration of fir, the distance between a mature forest stand that produces seeds cannot be too long because fir seeds are heavy. Years when fir is producing seeds and just after them, the cohorts of seedlings are very abundant under the maternal forest stand or in its nearest surrounding (Fig. 28).

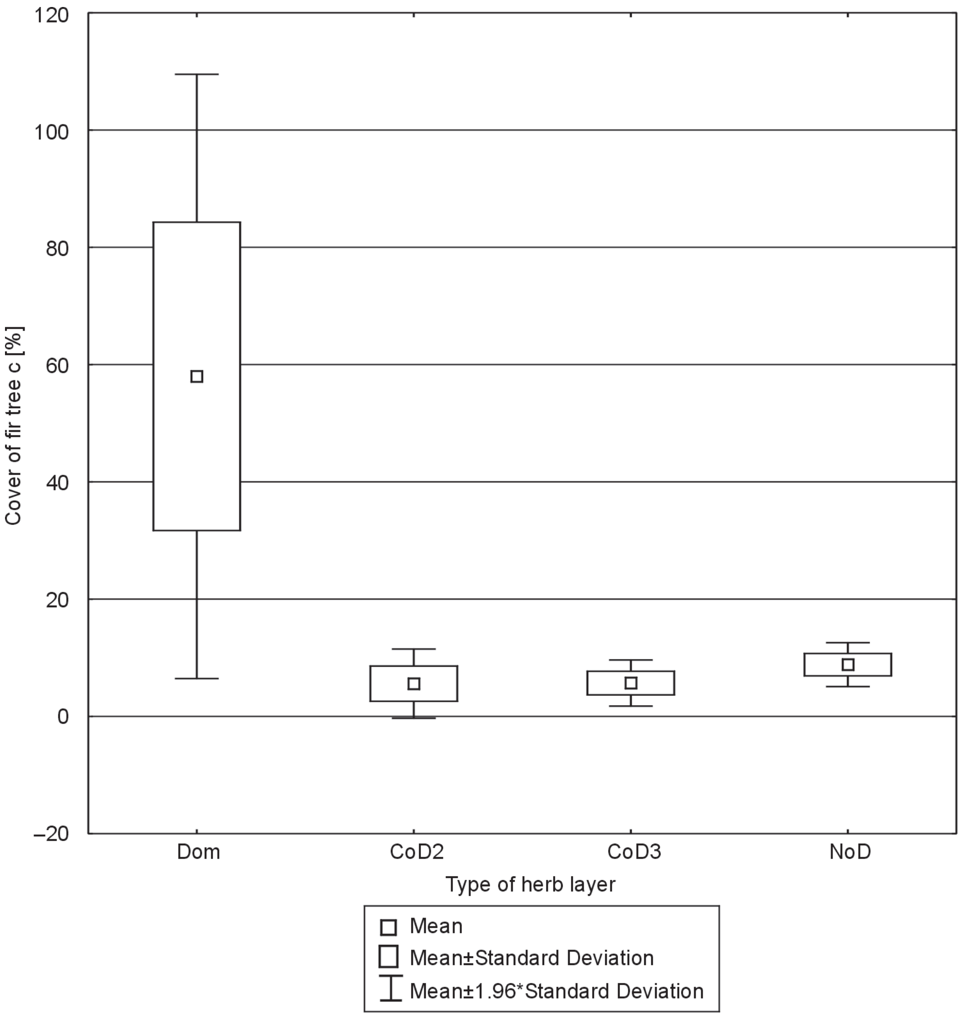

Fig. 28. Cover of fir in the herb layer differentiated into the dominance types

Explanations: Dom — fir as dominant species in cover of c; CoD2 — two dominants in c; CoD3 — three dominants in c; NoD — none dominant in c

New-growths of trees and shrubs of species different from silver fir. Despite the lack of hazel, new-growths included a richer (one to eight) set of species in the herb layer than occurred in the up-growths in the shrub layer. The group of species that combined for these two neighbouring layers of the forest (among others: rowan, sycamore, and birch) spruce, as well as cherry, maple, linden, ash, and elder in admixtures. In total, these species built only approximately 7% of the quantitative share of fir new-growths. Among them, only two species showed in higher numbers, although this was only 3.1% (rowan) and 2% (spruce) of the quantitative share of the fir. Then, it was fir new-growths up to a height of 0.5 m that numerically dominated in the herb layer in relation to young specimens of the other trees and shrubs (Table 13).

Table 13. Species and quantitative differentiation (N/4 m^2) of tree and shrub new-growths that were renewed in study units (I—VI)

No. of study plot		I	II	III	IV	V	VI	Sum*
Fir	Fr	180	371	18	27	86	147	829
Other species	Ro	4	15	0	0	5	2	26
	Sy	3	1	2	0	0	0	6
	Bi	0	0	0	0	0	3	3
	Ab	1	0	0	0	1	0	2
	Be	0	0	1	0	0	0	1
	Pi	0	1	0	0	0	0	1
	As	1	0	0	0	0	0	1
	Sp	6	4	0	0	5	1	16
	Ch	0	0	0	0	2	0	2
	El	1	0	0	0	0	0	1
	Ma	0	1	0	0	0	0	1
	Li	1	0	0	0	0	0	1
	Ah	0	0	1	0	0	0	1
Sum of specimens of other species		17	22	4	0	13	6	62
Sum of specimens in total		197	393	22	27	99	153	891
Sum of species		8	6	4	1	5	4	—

Explanations: **Ab** — alder buckthorn, **Ah** — ash, **As** — aspen, **Be** — beech, **Bi** — birch, **Ch** — cherry-tree, **El** — elder, **Fr** — fir, **Li** — linden, **Ma** — maple, **Sp** — spruce, **Pi** — pine, **Ro** — rowan, **Sy** — sycamore; **N** — number of specimens; * — on total area 24 m^2

The height of rowan new-growths included a range of 2—33 cm, although the majority of specimens (73%) did not exceed a height of five centimetres, and the next 15% — a height of ten centimetres. The height of spruce new-growths varied within a narrower range of heights from 3 to 11 cm, but it was still not possible for the majority (75%) of spruce individuals to reach ten centimetres of height. Both rowan (73%), as well as spruce (62%) new-growths were aggregated in the highest numbers in Goncerzyca; however, there were none in Hucisko. In the Trzyciąż locality, these two species occurred in similar numbers as in Goncerzyca locality (27% and 37%, respectively). This arrangement was repeated to a significant degree (see Fig. 22, 23 and 25) in the structure of dominance which was represented by fir new-growths. Fir new-growths reached the highest mean and maximum heights and the highest percentage of cover on Goncerzyca Rock while they had the lowest parameters in Hucisko locality. Not only the numbers of the species were highest in Goncerzyca, but also the species richness among new-growths. These parameters were lowest in Hucisko (see Table 13).

It must be emphasised that the regeneration was of a natural character and the origin of spruce seeds could be connected with the influence of the surroundings, but not the maternal forest stand in which this species did not occur in the tree layer on the permanent plots that were delimited for the presented structural studies. Rowan instead played an important role in the species composition and the structure of both the higher layers of the forest, that is, in the shrub layer (b) and in the forest stand (a_2).

4.6. Dynamics of the fir regeneration in the phytocoenoses of the *Abietetum albae* association

The presented studies from permanent study plots include the set of numerical data that were gathered in the vegetation season of 2011. Field data were collected from an area of 12 ares for the forest stand, 12 ares for the up-growths (including 2.4 ares for the inner subarea of the studies "i") and 24 m^2 for new-growths. This means that these studies belong to the so-called short-time ones, which in practice are conducted on small areas but with the possibility of repeating them in a short-time study series. The question formulated during the studies conducted on the permanent study plots in the central part of the Cracow--Częstochowa Upland was whether the actual resources of the fir in particular forest layers of the upland mixed coniferous fir forest are sufficient to secure an unbroken generational succession of this forest community? Specific answers are included in the above subchapters. However, there is a need to formulate a few general points resulting from the presented studies regarding the dynamic tendencies and generational continuity of *Abies alba* in the phytocoenoses of the *Abietetum albae* association.

Actually, in the central part of the Cracow-Częstochowa Upland on the three main study localities (Goncerzyca, Hucisko Ryczowskie, and Trzyciąż), there are multi-species and multi-generational forest stands of the *Abietetum albae* association in which fir is unquestionably dominant, both in relation to their numbers and quality features. Among others this statement is evidenced by: the wide range of diameters that were represented and the presence of big old firs which, in relation to their dimensions, are very close to the natural monuments. Rowan is the most important admixture species in the forest stand sublayer, but it has worse parameters of diameter and has a lower position in the vertical structure of the tree layer.

The fir resources of the up-growths seem to be insufficient. This was confirmed by the data gathered from 12 ares and 2.4-ares areas. Of the six study plots (I—VI), fir only occurred in that forest layer on four (I—IV), while the results of studies from the so-called inner subarea "i" (240 m^2 in total, delimited within the borders of all of the study plots I—VI) indicate the presence of fir up-growths on only one of the study plots that was analysed (I) from the Goncerzyca locality. This statement confirms the lack of fir trees as up-growths in the shrub layer (Table 14).

Table 14. Differentiation of silver fir *Abies alba* resources in particular layers of the forest (a, b, c) with differences resulting from the size of the data collection area in the shrub layer (b)

Layer \ No. of study plot	I	II	III	IV	V	VI	**Total I—VI**	Mean N/ha	Mean N/10 m^2	Mean N/m^2
Na^	6	9	8	11	6	5	**45***	375	—	—
Nb^	2	7	8	6	0	0	**23***	192	—	—
Nb^^	1	0	0	0	0	0	**1****	42	—	—
Nc^^^	180	371	18	27	86	147	**829*****	345 000	345	34

Explanations: ^ — on the area of 200 m^2 (2 ares); ^^ — on the area of 40 m^2; ^^^ — on the area of 4 m^2; * — on the total area of 1200 m^2 (12 ares); ** — on the total area of 240 m^2 (2.4 ares); *** — on the total area of 24 m^2; **N** — number of individuals

Fir did not compete with rowan in the shrub layer. These two species exchange with each other between plots or within the borders of the same plot — replace themselves in altitudinal zones of the forest (see Fig. 16 and 20). In addition, other up-growths such as birches, hazels, beeches or sycamores did not occur in such a quantity or density that they can be acknowledged as strongly competitive with the fir up-growths. The reasons for that state should be found in the structure and species composition of the shrub layer.

The results of the studies showed that at younger developmental stages (seedlings and new-growths up to a height of 0.5 m), the number of fir trees was sufficient. The fir quantitatively dominated in the herb layer in relation to the other trees and shrubs that formed new-growths. Part of the *Abies alba* individuals (34%) vegetated at the stage of seedlings and became a potential source of the resources for older new-growths. Fir new-growths aggregated most numerously in the mean range of the heights from 6 to 8 cm, and they rarely exceeded a mean height of eight centimetres. Fir met competitors like rowan and spruce new-growths in that altitudinal zone but the multiple quantitative superiority of fir over the other species of trees and shrubs radically eliminated effects of their presence. On the other hand, effective fir regeneration was negatively influenced by some vascular plants, in particular by *Rubus hirtus et pedemontanus* and *Oxalis acetosella*, which reached a higher cover and eliminated fir new-growths from the herb layer (see Fig. 26). The moss layer had no visible influence on the development of fir new-growths.

Thus, in order to maintain the generational continuity in the *Abietetum albae* phytocoenoses in the central part of the Cracow-Częstochowa Upland, particular attention should be paid to the protection of the fir up-growths.

5. Importance and state of maintenance of the fir forests in the central part of the Cracow-Częstochowa Upland

Considering the state of the art concerning the upland mixed coniferous fir forest in the central part of the Cracow-Częstochowa Upland, it was difficult to predict whether its role is important in the area being discussed. Such prerequisites as the practical lack of any documentary materials (see Medwecka-Kornaś 1952; Wika 1983, 1986, 1989; Hereźniak 1993; Wika et al. 2000; Wika, Barć 2011), the general assumption that only the edge shape of the *Abietetum albae* association can occur in a Jurassic area (Matuszkiewicz J. 1977, 2005) and also the common opinion concerning fir regression from Polish forests or even of fir forests decline did not facilitate the present studies. On the other hand, the results of the studies discussed in this monograph proved that *Abietetum albae* occurred in the central part of that region in at least ten new localities (see Chapter 1.1., Fig. 2).

The importance of the association in the landscape was rather small. Patches of the *Abietetum albae* association were dispersed and mainly covered not very large areas (with a few exceptions). As a rule, these were hidden among other forest communities and were located on the lower parts of slopes, entire valleys, or other low placed areas. In many cases, the phytocoenoses of the *Abietetum albae* association were concealed by surrounding beech woods or coniferous pine forests or mixed oak-pine forests. Sometimes these were oak-hornbeam-linden woods or acidophilous oak forests, and sometimes in some localities it was difficult to identify and interpret the secondary forest communities that had been modified by the forest management. Secondary arrangements on the potential habitats of the upland mixed coniferous fir forests (Table 4, rel. 28) were also hidden among the last one mentioned. According to preliminary observations, these communities were widespread in the central part of the Cracow-Częstochowa Upland. A more widespread potential area of the occurrence of this interesting association can be distinguished, based on the maps of fir distribution, as well as the other diagnostic species of the *Abietetum albae* association, for example, *Dryopteris* *dilatata*, *Rubus hirtus*, *R. pedemontanus*, and *Sambucus racemosa*), which were recently presented by Urbisz (2012).

The significance of the upland mixed coniferous fir forest in the central part of the Jurassic area is extremely important from a geobotanical point of view. Its presence strengthened the significant role of this area in relation to the protection of biological diversity. This type of forest is a valuable natural habitat in the international system of Natura 2000 with the code 91PO-1 (Hereźniak 2004; Ratyńska et al. 2010; Matuszkiewicz W. et al. 2012). It aggregates quite a rich flora of vascular plants and mosses. Among them, 18 species are protected by law (Regulation of the Minister of Environment — Dz.U. 2014, No. 0, pos. 1409) and 45 have been included into the regional red lists of threatened species (Parusel, Urbisz [eds.] 2012; Stebel et al. 2012).

Another fact worth mentioning is that documented phytocoenoses were well and very well developed as regards their structure and characteristic combination of species that formed them in the great majority. It must be stressed that these phytocoenoses represent a full, very wide differentiation that is embraced in the form of the two subassociations and variants. This differentiation can be interpreted as a continuous variability with not very sharp borders between the subunits, which can be seen on both Figures 4 and 5, which illustrate the results of the numerical analyses of the total material, as well as in the analytical tables (Tables 3 and 4).

In order to precisely evaluate the state of maintenance of the *Abietetum albae* association in the study area, the best way is to analyse particular documented localities of that association (see Fig. 2). All of the localities were placed within the borders of the Landscape Park of the Eagles' Nests (*Park Krajobrazowy Orlich Gniazd*), with the exception of locality no. 8, which was situated in the border zone of the Landscape Park of the Eagles' Nests and locality no. 10, which was situated within the borders of the Dłubnia Landscape Park (*Dłubniański Park Krajobrazowy*).

The Kaliszak reserve (locality no. 1!) was one of the two locations in the area of the central part of the Cracow-Częstochowa Upland where the upland mixed coniferous fir forest was protected under the law in two ways; it was also a part of the area Natura 2000, the so-called Olsztyn Refuge. Four phytosociological relevés were made in patches of the association (Table 3, rel. 4, 21 and 22; Table 4, rel. 27). A typical subassociation of the *A. a. typicum* can be found there (in the majority of the area of the local biochore with the *Milium effusum*). Moreover, in some places in the lower southern part of that locality a more fertile subassociation of the *A. a. circaeetosum alpinae* also occurred. The phytocoenoses had a completely developed layered structure. The upper sublayer of the forest stand (a_1) reached a mean density of 54% and the share of fir was evaluated at 2—4 degrees in the Braun-Blauquet's scale. Fir trees reached significant dimensions (heights of 35 m and a maximum diameter of 38—78 cm in particular patches).

The fir (*Abies alba*) was mainly accompanied by the pine (*Pinus sylvestris*) in that sublayer of the forest.

Fir was a dominant species and had a similar numerical share (2—4 degrees) in the lower sublayer of the forest stand (a_2) where its mean cover was 44%. The species regenerated well in the shrub layer (b) where it formed up-growths of a mean density at the level of 10%. It achieved 1—2 degrees in that layer, and coexisted and codominated with *Sorbus aucuparia*. The fir new-growths were numerous (abundance 1—2) in a mosaic that developed in the herb layer with a mean cover of 44%. It must be emphasised that, in general, the moss layer was also well developed in that reserve's upland mixed coniferous fir forest, which reached a mean cover at the level of 16%. The total number of species in patches varied within the range of 30—55 (45 on average). The state of maintenance and future conservation plans concerning the association, with maintaining phytocoenoses using the contemporary forms of passive protection without any cultivation activities should be evaluated as positively distinguishing one of the local patterns.

Locality no. 2 was situated to the west of Kolonia nad Dołami in the village of Stare Kiełkowice. As regards the problem being discussed here, it is a contrasting example of the development of phytocoenoses. One phytosociological relevé (Table 3, rel. 15) documented the *Abietetum albae typicum* phytocoenose that was distorted to a significant degree. That was revealed by the composition of both the stand and the herb layer species. A distinct dominance of planted spruce was noticeable in the stand, while many sporadic taxa which usually did not occur with upland fir forests, appeared in the herb layer. Their contribution distinctly enriched the total floristic richness of the forest. The state of maintenance of the association and its further preservation should be evaluated as critical. The influence of strong anthropopressure (cultivation activities, sheep grazing, the vicinity of secondary forest communities, increasing tourist movement) was crucial for its bad state.

Patches of the *Abietetum albae circaeetosum alpinae*, which were documented from the so-called Black Forest (*Czarny Las*) near the Wola Kocikowa village (locality no. 3*, Table 4, rel. 25—26) had a somewhat similar character. The spruce *Picea abies* that had been planted together with the admixture of pine dominated the forest stand there. Fir occurred mainly in the lower sublayer of the forest (a_2) but not numerously and weakly regenerated. One possible cause of that situation was the dense cover of the herb layer formed by vascular plants (80—90% of the layer cover) and mosses (50—60% of cover). These two dense layers made it difficult for fir new-growths to develop (see Chapter 4.5). On the other hand, within these phytocoenoses, very rich in relation to the number of taxa (61—63), valuable elements of the flora, which are characteristic for the *Piceion excelsae* alliance — *Lycopodium annotinum* and *Moneses uniflora* occurred. The developmental tendencies of these phytocoenoses are difficult to predict and are probably dependent on the forest management to a significant degree.

A. a. circaeetosum alpinae was documented as an exclusively fertile subassociation of the upland mixed coniferous fir forest on the locality 4 near the village of Hucisko Ryczowskie (Table 4, rel. 9—12). Soil studies were also conducted in the patches of this subassociation (Table 2) and two permanent plots were delimited in order to take measurements for the structure and dynamics of the forest stand (Chapter 4). Patches of the *Abietetum albae circaeetosum alpinae* were maintained in a very good state in the private forests that were extensively used by agricultural owners. In general, the management, which included the sporadic cutting of single trees, is quite similar to the passive reserve protection. Fir (with small admixtures of birch, beech, larch, pine, and spruce) undoubtedly dominated in the upper sublayer of the forest stand (a_1) with density of 60—70% (63% on average). Fir reached heights of 33—35 m and the maximum diameters were within the range of 53—62 cm.

Fir also dominated the lower sublayer (a_2) with a density of 15—40% (29% on average). Fir reached abundance degrees of 2—3 and was accompanied by beech, rowan, spruce, and sporadically sycamore in that sublayer. The shrub layer achieved a mean density of approximately 13% and was grown most numerously with the *Abies alba* up-growths (2nd degree) with an admixture of mainly *Fagus sylvatica*, *Sorbus aucuparia*, *Sambucus racemosa*, and locally with *Picea abies* of low vitality. Fir regenerated very abundantly in the new-growths. The herb layer (c) covered 40—65% (51% on average), while the moss layer (d) covered 5—25% (approximately 14% on average) of the soil surface in the phytocoenoses. This was favourable for fir regeneration (see Chapter 4.5). The floristic richness was quite stable (44—53, on average 49 taxa of plants in one relevé).

Locality 5, which is situated between the villages of Jaroszowiec, Pazurek, and Podlesice is quite vast and includes both forests that are protected within the borders of the Pazurek reserve on the southern side of Cisowa Rock (*Cisowa Skała*) and forests growing beyond the borders of the reserve on the SE side of the Pazurek—Rabsztyn road. Seven phytosociological relevés were made there in total. The association of the upland mixed coniferous fir forest *Abietetum albae* developed there as a typical subassociation and a typical variant (Table 3, rel. 1, 6, 7, 12, 13) and quite rarely as a subassociation *A. a. circaeetosum* (Table 4, rel. 19 and 21). The higher sublayer of the forest stand (a_1) reached a density of 40—80% (approx. 70% on average) there and fir reached an abundance degree that ranged from 2 (exceptionally) to 4 on the Braun-Blanquet's scale, maximum heights were 29—31 m and diameters (dbh) were 45—60 cm, which is an evidence of good conditions. Fir was accompanied by beech and spruce (locally even numerously) in the majority of the patches, and rarely by aspen and sporadically by birch and pine. The lower sublayer (a_2) was not very strongly developed. It reached a density that ranged from 10 to 50% (24% on average).

With the exception of fir, which reached abundance degrees of 1—2, beech and spruce were also quite dispersed. The shrub layer (b) was barely developed in comparison with the other localities. It had an average density of approximately 5% (from insignificant to 15%). Fir was not always present and its abundance ranged from + to 2. *Sorbus aucuparia* was the most frequent species in that layer, beech up-growths occurred more abundantly locally, whereas young spruce specimens revealed a distinct lack of vitality. The herb layer covered 15—25% (21% on average) of the soil surface and the moss layer ranged from insignificant to 35% (approximately 10% on average), which should be favourable for fir regeneration. Unfortunately, fir occurred only in average numbers in new-growths. In each case, it had a low numerical force — one (i.e. the cover up to 5%). The patches studied were floristically stable, but not very rich in species (30—40, on average 36 taxa in the relevé).

The state of preservation of the *Abietetum albae* phytocoenoses on locality 5 should be assessed as quite differentiated — from medium to good (in general acceptable). However, it must be stressed that patches that were beyond the reserve borders were much better preserved than those within the reserve. The Pazurek reserve was established mainly for protection of beech woods (Wika et al. 1984; Wika 1986; Rąkowski 2007). Perhaps the area of the reserve should be expanded to the forests that are situated on the SE part of the Pazurek—Rabsztyn road for the protection of the upland mixed coniferous fir forest association.

Locality 6! — which is quite vast in area (see Fig. 2) — included the forests of the Wodąca Valley (*Dolina Wodąca*) (Wika et al. 2000; Wika, Barć 2011; Wika 2012). These were protected within the Eagles' Nests Landscape Park. The idea of the establishment of one large reserve (over 50 ha) that included a significant part of the Wodąca Valley was discussed. The reserve would be organised for the protection of *Phyllitis scolopendrium* (Wika 2012). Parts of the fir forests would also be within the borders of that reserve.

Phytocoenoses of the upland mixed coniferous fir forest covered quite a significant area there, almost exclusively in forests used by private agriculturalists. Sixteen phytosociological relevés were made — 15 in *A. a. circaeetosum alpinae* (Table 4, rel. 1—8, 13—18 and 20) and one in *A. a. typicum* in a typical variant (Table 3, rel. 14). Soil studies (Table 2) and two permanent plots for studies on the structure and dynamics of the stand regeneration (Chapter 4) were conducted there. All of these phytocoenoses of the association had a classical layered structure. Fir distinctly dominated in the upper sublayer (a_1) with an average density of 60% (50—75%). Fir reached high numerical degrees (3—4), and had significant dimensions of the trunks regarding their heights (25—36 m; 32 m on average) and diameters (dbh), which in particular patches varied within a range of 31 cm and 58 cm. Fir was almost always accompanied by *Picea abies*; *Betula pendula*, *Fagus sylvatica*, *Pinus sylvestris*, and *Populus tremula* were also frequent; *Acer pseudoplatanus* and *Quercus robur* rarely appeared. Fir was also well regenerated in a_2 layer. *Sorbus aucuparia* was an accompanying species to fir in almost 70% of phytocoenoses studied. The numbers of rowan ranged between + to 2 on the Braun-Blanquet's scale. In addition to fir and rowan, such species as: *Acer pseudoplatanus*, *Betula pubescens*, *Corylus avellana*, *Fagus sylvatica*, *Picea abies*, *Quercus robur*, and *Salix caprea* were also noted in the lower sublayer of the tree stand (a_2). Particular attention should be paid to *Corylus avellana*, which occurred numerously as up-growths in the shrub layer (layer b) in the Vth constancy class and with a significant abundance that ranged from 1 to 2. The mean density of that layer amounted to 18% and in particular phytocoenoses varied between 5 and 20%. The layer was built by both well-regenerating up-growths of *Abies alba* and by such species as *Acer pseudoplatanus*, *Fagus sylvatica*, *Populus tremula*, and rarely by *Picea abies*. *Sambucus nigra* and *S. racemosa*, and also *Frangula alnus*, were among the typical shrubs but rarely noted.

Fir new-growths were numerous (numerical force 1—2) in the herb layer (c) with an average cover of 42%. *Luzula pilosa*, *Maianthemum bifolium*, *Oxalis acetosella*, *Vaccinium myrtillus*, and ferns, especially: *Athyrium filix-femina*, *Dryopteris carthusiana*, *D. dilatata*, and *Gymnocarpium dryopteris* reached the highest constancy classes (V—IV). With the exception of *Vaccinium myrtillus*, their cover was not high; they usually numbered + to 1; rarely were they higher than a value of 5%.

The moss layer was always present and amounted to 18% of cover on average (but with high variations of this parameter from 5 to 50%). The layer was formed primarily by seven moss species, namely, *Atrichum undulatum*, *Brachythecias-trum velutinum*, *Dicranella heteromalla*, *Hypnum cupressiforme*, *Plagiothecium curvifolium*, *Pohlia nutans*, and *Polytrichastrum formosum*. The number of species in patches varied within the range of 36—56 (on average it amounted to 46). The state of maintenance and future preservation plans of the association in the Wodąca Valley should be acknowledged as very good. These were one of the local patterns in management of fir resources.

On locality 7, that is, in the Łysa Forest (*Las Łysa*), (Fig. 2), only two phytosociological relevés were made, both in the subassociation *A. a. circaeetosum alpinae* (Table 4, rel. 22—23). The Łysa Forest joins the Kleszczowski Forest (*Kleszczowski Las*) making one large forest complex that is situated in an open agricultural landscape between two localities — Kleszczowa—Udórz on the north and Kąpiele Wielkie—Poręba Dzierżna on the south. The two phytosociological relevés included the two small phytocoenoses that had developed on the slopes on the northern and the north-eastern exposures of Bald Mountain. The forest stand (especially in the upper sublayer a_1) was distinctly loose because a few larger firs had been cut, however, despite that the structure of patches of the association studied was complete. Fir occurred only under the canopy of spruce in one of the patches. Fir was present in the shrub layer as up-growths; however, it very weakly regenerated in the herb layer in contrast to the spruce *Picea abies*, which was abundantly represented in the shrub and herb layers and dominated in the upper sublayer of the stand (a_1). It was accompanied quite numerously by *Quercus robur* there, while *Fagus sylvatica* and *Sorbus aucuparia* were in a good condition (bonitation) in the sublayer a_2. Attention should be paid to the other species that are present in these phytocoenoses, namely, *Eurhynchium angustirete*, *Gymnocarpium dryopteris*, *Herzogiella seligeri*, *Impatiens parviflora*, *Lophocolea heterophylla*, *Phegopteris connectilis*, and *Sambucus racemosa*. *Impatiens parviflora*, which appeared in the herb layer and as an alien species to the country flora, indicated an ongoing process of degeneration. The process was caused by the promotion of spruce by the forest management service, and therefore the state of maintenance of the association and its further persistence should be assessed as critical there.

Locality 8 was situated on both sides of the forest road that links Zabagnie and Domiarki, which are small village communes. The forest complex called The Zabagnie is situated NW from the town of Wolbrom and the village administrative unit of Dłużec (Fig. 2). Patches of *Abietetum albae typicum* (Table 3, rel. 8—11), which covered among other forest communities and were dominated by *Picea abies*, developed on the flat areas, and only in some places that were a bit uneven. The phytocoenoses had a fully developed layered structure. The upper sublayer of the forest stand (a_1) reached a mean density of 66% and the maximum diameters of firs (dbh) ranged from 36 to 44 cm. The heights of the trees in the stand reached 33 m. *Picea abies*, with abundance degrees on the Braun-Blanquet's scale of 2—3 dominated in the forest stand, whereas fir achieved degrees only of one to two. Both of the species mentioned were accompanied by *Betula pendula* (with degree of two) and *Pinus sylvestris* occurred less numerously. *Populus tremula* and *Quercus robur* rarely occurred. In the lower sublayer of the forest stand (a_2), both fir and spruce were codominant species with a mean density of 31%. *Padus avium*, *Quercus robur*, and *Sorbus aucuparia* were not a numerous admixture.

The shrub layer (b) reached a mean density of approximately 15%. *Abies alba* was always present with abundance degrees from 1 to 2. *Picea abies* and *Populus tremula* showed a distinct lack of vitality. *Corylus avellana*, *Sambucus racemosa* and *Sorbus acuparia* were observed in each patch of the shrub layer. Fir new-growths were numerous (abundance degrees from 1 to 2) in the mosaic developed herb layer with a mean cover of 53%. *Pteridum aquilinum* occurred quite abundantly in the half of phytocoenoses that was studied. *Lycopodium annotinum* and *Pyrola minor* were noted in the herb layer sporadically. The moss layer (d), which reached a mean cover of 8%, was composed of 16 moss species, including a few that were rare for the Cracow-Częstochowa Upland (Fojcik 2011), for example, *Hylocomium splendens, Kindbergia praelonga, Ptilium crista-castrensis*, and *Thuidium tamariscinum*. The number of species in particular phytocoenoses ranged from 36 to 44 (37 on average). The state of maintenance and the perspectives of further persistence should be assessed positively as acceptable. Actually, the forest service pays a lot of attention to the preservation of the upland fir forests in that area, where it has good conditions for development. Spruce (*Picea abies*) has actually been eliminated in many places where it was strongly promoted for many years in the past. The regeneration of fir in "nests" was undertaken in order to promote succession in the direction of a "target forest stand," taking into consideration the rules of multi-functional forest management and for the purposes of the restoration and protection of an adequate association. This was the only case of such activity that was recorded during these studies.

Locality 9 for *Abietetum albae* (small in area) was situated in the Michałówka village, to the east of the Michałówka—Cieplice local route, to be more precise on slopes of Mt. Łysica (*Góra Łysica*) (444 m a.s.l.) and on a nameless hill (454 m a.s.l.). These two hills are situated in the vicinity of the Michałowiec reserve, which is located a few kilometres in a straight line from locality 9. In total, four phytosociological relevés were made on locality 9; two relevés were made in the *A. a. typicum* in a variant with *Milium effusum* (Table 3, rel. 23 and 24), and two in the *A. a. circaeetosum alpinae* (Table 4, rel. 24 and 28). However, the second relevé represents the poorer shape of the association and demands a separate description. All phytocoenoses that were studied were situated on the lower parts of the hills mentioned above, whereas the tops were covered by beech woods, namely, orchidaceous *Cruciato glabrae-Fagetum* (Michalik 1972) Ratyńska et al. 2010 *pro ass*. [=*Carici-Fagetum convallarietosum* Michalik 1972, community *Fagus sylvatica-Cruciata glabra auct*.] and an acidophilous lowland beech wood *Deschampsio flexuosae-Fagetum* [=*Luzulo pilosae-Fagetum*]. The four-layered structure and very high forest stand of the upland mixed coniferous fir forest (mean height 30 m) is comprised mainly of spruce with a lower share of the fir. Fir is not numerous in layer b as up-growths, and moreover, its new-growths were weakened in the herb layer (abundance degrees r–+). The maximum diameter of firs varied with a range of 30—31 cm. The moss layer did not exceed 10% of the cover and the floristic richness was unstable (29 to 49 species).

Relevé number 28 in Table 4 differs quite distinctly from the others that represent the phytocoenoses discussed above. *Athyrium filix-femina* (3.3), *Impatiens parviflora* (2.1), and *Rubus hirtus* (3.4) achieved a total cover of 70% in the herb layer, which are high numerical degrees. *Pinus sylvestris* (3.4) dominated in the forest stand with an admixture of *Picea abies* (2.1), *Quercus robur* (2.3), *Betula pendula* (1.1), and *Fagus sylvatica* in a_2 (2.3). Fir was only represented there in the sublayer a_2 (1.1) and in the shrub layer (b) but with a low abundance degree (+).

The state of maintenance of *Abietetum albae* and further persistence of this association on the locality being discussed should be assessed as critical. The reasons are the especially strong anthropopressure (forest management, visible cattle grazing, locality in the neighbourhood of secondary forest communities, and most of all, isolation of that rather small locality). It must be added that both of the hills where the four phytosociological relevés were made, were surrounded on three sides by agricultural lands and only on one side (the north-eastern) there was a narrow strip of forest from the side of the village of Cieplice where it joined the locality being discussed.

The last locality (no. 10*) — the largest in relation to area and the locality of the *Abietetum albae* association on the area studied was situated within the Dłubnia Landscape Park. It is a forest complex that stretches between the villages of Trzyciąż, Zagórowa, and Glanów. These are mainly State Forests that are under the administration of the Trzyciąż Inspectorate. In total, eight phytosociological relevés were made on both sides of the Trzyciąż—Zagórowa road. These represent a typical subassociation that is differentiated into two variants — a typical variant (Table 3, rel. 2—3 and 5) and a variant with *Milium effusum* (Table 3, rel. 16—20). Soil studies were also conducted (Table 2) and two permanent plots were delimited in order to take measurements on the structure and dynamics of the fir stand (Chapter 4). As was said earlier (Chapter 3.2), the fir reached significant dimensions there, which were similar in values to those from the Kaliszak reserve. The maximum height of its trunks amounted in that case up to 36 metres and the maximum diameter was sometimes up to 90 cm (59 cm on average). In the majority of cases, the phytocoenoses had a completely developed layered structure. *Abies alba* dominated in the upper sublayer of the forest stand (a_1), while in the lower sublayer (a_2) only in two cases of the phytocoenoses studied was its abundance assessed as one; in other cases it ranged from two to four. In the two other layers, that is, in the shrub layer (b) and in the herb layer (c), fir regenerated extremely well in contrast to *Picea abies*. Spruce revealed a lack of vitality, which was particularly visible in the shrub layer (b). Fir was almost always represented in layer b despite the fact that the density of the species in that layer was changeable from 1 to 20% (11% on average). However, fir took first place in respect to its quantity. *Sorbus aucuparia*, *Sambucus racemosa, Corylus avellana,* and *Frangula alnus* had lower numbers in that layer.

The presence of *Galeopsis pubescens, Impatiens parviflora*, *Ranunculus repens*, or *Urtica dioica* in the herb layer indicate the degeneration of the phytocoenoses. This was also confirmed by the unstable percentage values of the density and cover of plants in particular vegetation layers, for example, in the a_1 values, which ranged between 40—85%, whilst in a_2, — they ranged from 10 to 60%, in b from 1 to 20%, in c from 30 to 75% and in d from 5 to 40%. During the field studies traces of intensive forest management were noticeable in many places.

To date the state of maintenance of the upland mixed coniferous fir forests on the localities being discussed should be acknowledged as good. The developmental tendencies of these phytocoenoses are difficult to predict and are dependent on the sylvicultural activities that are conducted there to a significant degree. A loose forest stand creates unfavourable conditions for fir regeneration because it is connected with the rapid appearance of nitrophilous species, especially *Impatiens parviflora*, which are alien to the flora of the country.

To summarise this chapter, it must be ascertained that the state of maintenance and further perspectives for the persistence the upland mixed coniferous fir forest in the area of the central part of the Cracow-Częstochowa Upland are quite differentiated. The Kaliszak reserve (1!) should be acknowledged as of a very good or even distinguished maintenance status of fir forests, as well as in the case of localities 4 and 6!. Only locality no. 10* has good status of fir forests. Satisfactory status have localities 3*, 5, and 8; while bad — 2, 7, and 9. The further persistence of this association should be assessed as critical on the other two localities. Localities 3* and 10* have an asterisk, which means that the developmental tendencies of the *Abietetum albae* are difficult to predict today and are dependent on forest management, to be more precise — on the direction it takes in the nearest future. Localities 1! and 6! should be distinguished because of the positive local patterns of use and the management of upland mixed coniferous fir forest.

6. Discussion

In earlier studies that have been conducted in the central part of the Cracow-Częstochowa Upland, fir has been noted as a rare component of various types of beech woods, but was also found sporadically in oak-linden-hornbeam woods and acidophilous oak woods, mainly in up-growths and new-growths (Michalik 1972; Celiński, Wika 1975, 1978; Wika 1983, 1989, 2012; Wika et al. 1984, 2000). Fir forests were not distinguished in the Cracow-Częstochowa Upland, with the exception of the imprecise information given by Medwecka-Kornaś (1952) from the southern part of that region and the materials collected by Hereźniak (1993) from the northern part. The few phytocoenoses with a high share of *Abies alba* that were observed during the studies mentioned above have been consciously omitted and therefore treated as difficult to interpret the phytosociological degeneration shapes of beech woods (Wika, personal information). The species has been acknowledged there and at that time (Wika 1986) as a regressive species, which was the result of air pollution, cutting and the transformation of forest stands. A similar trend was observed by Medwecka-Kornaś and Gawroński (1990, 1993) in the widely treated mixed coniferous forests of the Ojców National Park.

For some period of time the statement (see Matuszkiewicz J. M. 1977, 2005; Matuszkiewicz W., Matuszkiewicz J. M. 1996) that the only edge shape of the *Abietetum albae* Dziubałtowski 1928, which is slightly different from the type, which for a few decades (in some elaborations up to contemporary times) was known under the improper name the *Abietetum polonicum* (Dziub. 1928) Br.-Bl. et Vlieg. 1939, can occur in the Jurassic area (see ICPN, Weber et al. 2000). In the meantime, the studies and research presented in this monograph proved that the association is present within the area of the central part of the Cracow-Częstochowa Upland on at least ten localities (including some that are quite large). The association was well developed in the majority of localities and had an acceptable condition and in many places revealed a high capability for spontaneous regeneration (improvement of its actual state) in cases of deformation. Moreover, the association presented the full spectrum of the known local-habitat variabilities that are realised in the rank of the two subassociations (*Abietetum albae typicum* J. M. Matuszkiewicz 1977 and *A. a. circaeetosum alpinae* J. M. Matuszkiewicz 1977) and also in the two variants within the typical subassociation.

The carried out comparative studies (Table 5) prove the distinguishing of the shapes of the upland mixed coniferous fir forest in the rank of new, Jurassic geographical variety of that association, but not its edge shape, which was documented in the research area. This should also be done with all of the other regional shapes of *Abietetum albae*, which developed in areas that are distant from the Holy Cross Mountains — the *locus classicus* of the association, where it theoretically occurred in its most typical form. However, the data included in the original Table 5, as well as the contemporary studies of Matuszkiewicz J. M. and Kowalska (2007) indicate that even there the association is slowly losing its regional specificity. On the one hand, it is becoming poorer in some important components, while on the other hand, it is incorporating new elements that partly come from other varieties, for example, *Corylus avellana*. In fact, the shape of the fir phytocoenose that occurs in the Siedlecka Upland can be acknowledged as an edge shape that is significantly poorer in important elements of the characteristic combination of species (Marciniuk, Wierzba 2004). However, it has the specific features of the Mazovian variety, which is also discussed in that book.

The Subcarpathian variety is controversial and demands further studies. This variety was distinguished by Matuszkiewicz J. (1977) and is very widely understood. It is probably a heterogenous unit that is differentiated into altitudinal zones. Moreover, it reveals features thanks to which it can be treated as "edge shape" according to Matuszkiewicz J. (1977) in order to recall the significant poorness of the group of diagnostic species for the association. More details and explanations are needed in relation to the problem of the identification of the phytocoenoses of that variety in the context of their separateness from the lower montane mixed coniferous fir-spruce forest, which is traditionally named the *Abieti-Picetum* (*montanum*) W. Mat. 1967, or the even lower montane fir wood *Galio rotundifolii-Abietetum* Wraber 1955, which have been characterised in more detail in Poland by Celiński and Wojterski (1978), as well as by Kasprowicz (1996a).

It seems probable that at least part of materials that have been interpreted within the variability of *Abieti-Piceetum* (*montanum*), which come from the lower Carpathian ranges, represent the upland coniferous mixed fir forest *Abietetum albae* (e.g. Barć 2012).

The problem of the relationship of the upland mixed coniferous fir forests of Poland to similar communities from the other countries of the Central Europe is beyond the scope of this book and requires separate studies.

The aspects discussed above, in general, good state of maintenance of the *Abietetum albae* association, its regeneration tendencies, and its specific features in the central part of the Cracow-Częstochowa Upland, which are characterised based upon phytosociological studies and comparative syntaxonomic studies within a certain range, have been confirmed by some exemplary soil studies. These studies revealed a strong relationship of the association with grey Luvisols. In general, good condition of the association with fir as one of the base species (and sometimes the most important) that builds the phytocoenoses in a particular way are illustrated during the studies on the structure and dynamics of the chosen species, which are presented in Chapter 4. A few questions discussed in that chapter require some additional comments.

The forest stand. Fir occurs in the stand with a mean density of 375 individuals/ha on permanent plots in the central part of the Cracow-Częstochowa Upland. As an example, in the strictly protected beech-fir forest in Kamień (the Magura National Park, the Beskid Niski Mts.) (*Magurski Park Narodowy*, *Beskid Niski*) in which fir amounted to 44.9% of the number of trees (Przybylska 2003), a number of 693 individuals of the total number per one hectare has been acknowledged as high. Fir coexists there, among others, with beech (47.5% of the number of trees) and sycamore (1%). A recalculation of the number of individuals for the share of the fir only, gives the number of 311 individuals/ha, thus 64 firs/ha less than the density that was indicated in the present studies for the Jurassic area.

In addition to fir, the structure of the forest stand of the *Abietetum albae* on permanent study plots I—VI in the central part of the Cracow-Częstochowa Upland is built by a few other species of trees. In the lower sublayer (a_2) of the upland mixed coniferous fir forest, a significant share of rowan was observed (100 individuals/ha) and a distinctly lower share of beech (25 individuals/ha). Other species comprising the stand on the permanent plots, that is, pine, birch, sycamore, and big hawthorn did not exceed ten individuals per hectare. The share of rowan, which significantly exceeded the number of other species, indicates a possible episode that was connected with the rapid cuttings of the tree stand in the past.

Up-growths and shrubs. Plot V in Trzyciąż is distinguished with regard to the number of individuals of all species in the shrub layer (b). Trzyciąż V is also one of the two plots where fir does not create layer b with other species. On the other hand, on Goncerzyca (plot I) the layer b consists exclusively of *Abies alba*. These examples give evidence of how different the possibilities for the development of that layer can be, depending on the history of the given phytocoenose or local-habitat conditions (see Tables 3 and 4).

The presence of 192 fir individuals/ha of fir up-growths in the central part of the Jurassic area was observed in the studies. This is a low number in comparison, for example, with fir up-growths in the Jata reserve on the Siedlecka

Upland, which developed under a dense and monospecies canopy of fir that grows there on the edge of the range of *Abies alba*. The layer is differentiated by the youngest up-growths from 0.5 to 1.3 m in height (246 individuals/ha), up-growths with diameters up to two centimetres (185 individuals/ha), as well as older up-growths with diameters of 2—7 cm (546 individuals/ha) (Dobrowolska 1998).

These relationships become clearer in a situation in which certain methodical solutions are used. In many space-wide field studies, in order to equalize the proportions between the area of sampling in the forest stand and in the shrub layer, an internal area a few times smaller than the area of the entire study plot is used. Such a solution was also used in these studies. On each of study plots (I—VI) with an area of 200 m^2 and internal subarea "i" that included 40 m^2 designated for studies on the up-growths was delimited; moreover, units of an area of 4 m^2 were used for the studies on new-growths. In this way the studies became more comparable with the results of the studies that had been done by other researchers. On the other hand, the methodical compactness between the phytosociological studies, soil profiles, and studies on permanent plots required data collection from all of the permanent plots (I—VI), that is, from 200 m^2 of each area. An expected and interesting difference between the numbers and the species richness of components of the shrub layer (b) which was obtained, was caused only by the size of the area of sampling.

Tables 15 and 16 were created in order to compare the numbers and species richness of all of the up-growths that were growing exclusively in the internal subarea "i" of study plots I—VI (of a 2.4-ares area) and the numbers and species richness of all of the up-growths that occurred on the area of 12 ares.

Table 15. Numerical differentiation (N/study plot) of the shrub layer with multi-species up--growths depending on the area of sampling

Number of study plot	I	II	III	IV	V#	VI#	Σ
Sum of individuals b*	2	27	26	9	45#	16#	125
Sum of individuals b**	1	5#	8#	5#	3#	6#	28

Explanations: N — number of individuals; # — lack of fir in the shrub layer; * — on total area 1200 m^2 (12 ares); ** — on total area of 240 m^2 (2.4 ares)

Table 16. The comparison of species differentiation (N/study plot) of the shrub layer depending on the area of sampling

Number of study plot	I	II	III	IV	V#	VI#
Sum of species b*	1	6	4	3	6#	2#
Sum of species b**	1	2#	2#	2#	3#	2#

Explanations: N — number of individuals; # — lack of fir in the shrub layer; * — on total area 1200 m^2 (12 ares); ** — on total area of 240 m^2 (2.4 ares)

As was expected, lessening the area of the sampling caused a reduction in the numbers and the species richness of up-growths, especially fir, in the shrub layer. However, this did not change the general rules that were indicated on the broader study material. All of the types of structure of fir phytocoenoses (Types 1—3, cf. Chapter 4.1) that had been distinguished earlier, based on forest stands and up-growths are still represented. Particular permanent plots represented by the described structural types proved to be changeable.

In the present studies, the highest number of fir up-growths that occurred on the study plots I—IV had diameters that ranged from 3.1 to 4 centimetres. Fir up-growths achieved the highest mean value of the diameter on study plot no. I (Goncerzyca), while the lowest was achieved on study plot no. III (Hucisko). The greatest number of *Abies alba* individuals in the up-growths were concentrated in a vertical range of 2.1 to 5 metres of height.

The highest number of rowan up-growths had the lowest range of diameters that ranged from 0.1 to 1 cm; these were aggregated on permanent plot II in Goncerzyca, as well as on plots no. V and VI in Trzyciąż that had no fir up-growths. Rowan up-growths were not competitors with fir in relation to the space; rowan appeared in up-growths in larger numbers in places where fir was absent and to a certain degree was a promoter species for the fir. Birch, hazel, beech and sycamore up-growths and shrubs did not occur on permanent plot I; and on the others these species did not exceed a diameter of five centimetres and did not grow taller than five metres.

Fir new-growths (with seedlings). On average, there were 34 fir new-growth individuals/m^2. Seedlings comprised 34% of all of the individuals in the category of new-growths up to 0.5 m in height. On average this applied to 12 individuals/m^2, but the numerical values were different depending on the plot and ranged from 4.5 seedlings/m^2 (Goncerzyca I and Hucisko III) up to 34.5 seedlings/m^2 (Goncerzyca II). These values ensure the sufficient restoration of the *Abies alba* new-growths within the permanent study plots in the central part of the Cracow--Częstochowa Upland. For comparison, it must be added that fir new-growths, which formed herb layer under the canopy of the mother stand in the the Holy Cross National Park (*Świętokrzyski Park Narodowy*) (Graniczny and Ukleja--Dobrowolska 1990), have been acknowledged as abundant, when these reach from 2 to 73 individuals/m^2.

Favourable and unfavourable species for fir. In the central part of the Cracow-Częstochowa Upland fir is accompanied by forest stand forming species or admixture species, their up-growths and sometimes shrubs in each of forest layers: the stand, the shrub layer, and the herb layer of the phytocoenoses of the *Abietetum albae* association.

According to Jaworski and Zarzycki (1983), the stand species composition is important for the natural restoration of fir. Trees can be differentiated into favourable, unfavourable, and neutral species regarding their effect on fir restoration. Monospecies fir stands have been acknowledged as the most favourable to the abundant natural regeneration of fir in the Jata reserve (Dobrowolska 1998). In the studies mentioned above, the positive influence of pine and birch to initiation and development of fir new-growths and up-growths has also been confirmed. Hornbeam, which is not represented in the stands of permanent plots I—VI in the central part of Cracow-Częstochowa Upland, has been acknowledged as a species that is unfavourable to fir regeneration. Dobrowolska (1998) did not indicate the presence of beech (this is understandable, because of the permanent lack of this species in the said area because the area is out of its natural range) and rowan in the lower sublayers of the stand in the Jata fir reserve. Such components of the stand as ash, black alder, durmast, maple, elm, and spruce are regarded as neutral for fir regeneration (Jaworski, Zarzycki 1983; Dobrowolska 1998). None of them is present in the forest stand of the patches of the *Abietetum albae* from plots I—VI that are being discussed.

The stands of the phytocoenoses of the *Abietetum albae* being discussed are multi-species but they are dominated by fir. In addition, the range of diameters that they represent is very wide. Nevertheless, the problem of fir regeneration under its own canopy is interesting and controversial (Šimak 1951; Mayer 1960; Gürth 1988; Ammer 1996). The idea that young firs have better conditions for regeneration under a canopy of mixed forest stands than those under their own mother fir stands, that is, with a fir share of more than 90%, is more popular. However, Gürth (1988) states that in such a case, natural even-aged fir stands would not occur (very equalized stand according to the diameters occurred in Hucisko IV). This argumentation is also questioned by the thesis concerning the replacement of species in a mixed forest stand. At that time an argument concerning the anthropogenic origin of even-aged (even those at an extremely advanced age) fir forests is given (Szafer 1932; Nožička 1957; Michalik S., Michalik R. 1997; Hofmeister et al. 2008).

Even-aged and monospecies forest stands can also be created as a result of mass phenomena that sometimes have catastrophic results.

Fir as a species that is strongly rooted in the soil and that develops the so--called medium or cordial root system is resistant to wind throws, and rarely undergoes windbreaks, because it usually has desirable proportions of the diameter to the height of the trunk. However, the species is not resistant to freezing to death, air pollution, a mass invasion (gradation) of insects, and the pressure of ungulates. In the past, the area of the central part of the Cracow-Częstochowa Upland (Jurassic area) was not immune from any of the above-mentioned mass phenomena (Paczoski 1929; Medwecka-Kornaś 1952; Medwecka-Kornaś, Gawroński 1993).

In reality, it seems (the problem needs further studies) that animals and in particular the deer family (*Cervidae*), may be responsible for the low share of fir in the up-growths on the area of the studies being discussed. Only these fir individuals that were taller than two metres persisted in the shrub layer on study plots I—VI, whereas only 9% of fir up-growths occurred in the range of 0.5—2 m. There is also a lack of fir new-growths in the height range of 0.2—0.5 m and rowan new-growths from 0.35 to 0.5 m. Sycamore at the stage of new-growths, which is acknowledged as a dainty for cervoids, did not grow higher than 0.36 m, and in up-growths occurred more numerously in the range of 1.6—2 metres.

A reduction in fir regeneration can also have other sources. *Athyrium filix-femina*, *Oxalis acetosella*, and *Rubus hirtus et pedemontanus* are accompanying species that occurred with *Abies alba* in the new-growths on all of the study plots I—VI. *Rubus hirtus et pedemontanus* and *Oxalis acetosella* (see Chapter 4.5) are distinctly unfavourable species for *Abies alba* in the new-growths within the phytocoenoses of the *Abietetum albae* in the central part of the Cracow-Częstochowa Upland. The values of correlation coefficients in both cases amounted r = −0.9 and r = −0.8, respectively, and such a correlation is highly statistically significant. *Rubus hirtus sensu stricto* is dangerous for fir regeneration because — as has been indicated in quantitative studies (Pancer-Koteja et al. 1995) — it has no mechanisms that can prevent the excessive density of its population, it has low mortality of sprouts in successive years and it has a domination of vegetative over generative reproduction. All of these features raise the competitive abilities of that species in relation to other components of the herb layer.

The phytosociological descriptions of the community of the type *Abies alba — Rubus hirtus*, which usually represents the *Fagetalia sylvaticae* order, have been presented from various parts of Poland for many years (among others, from the Beskid Niski Mts. and the Beskid Mały Mts.). These communities were often accompanied by the comment that the interpretation of their status within a hierarchical set of units is difficult and requires verification (Staszkiewicz 1973; Święs 1974a, b; Medwecka-Kornaś 1976; Michalik S., Michalik R. 1997; Michalik 2003; Barć 2012). The attention of researchers is paid to the share of anthropopressure in the transformation of the species combination of the stands and on the removal or promotion of fir, depending on the actual needs (Dziubałtowski, Kobendza 1933; Głazek, Wolak 1991). On the one hand, *Rubus hirtus* in relation to the *Abietetum albae* association, is mentioned as fir accompanying species, but not as the identifying species for the phytosociological unit (Głazek, Wolak 1991). On the other hand — more frequently — it is noted as the species that regionally and in the altitudinal zone differs this association within the alliance and suballiance (Matuszkiewicz J. M. 1977, 2005; Brzeg, Rutkowski 2004; Matuszkiewicz J. M., Kowalska 2007; Ratyńska et al. 2010; Matuszkiewicz W. et al. 2012).

Athyrium filix-femina did not show any distinct relationships with fir in the new-growths on study plots I—VI, which can be described as certain regularity. In addition, the total cover of *Dryopteris carthusiana*, *D. dilatata*, and *D. filix-mas* indicated a very low correlation r = 0.03 with the cover of fir new-growths. This is probably because of the distinct shadow-tolerance of *Abies alba* in the juvenile and mature stages of development; other species like *Athyrium filix-femina* and other ferns are not as dangerous for its regeneration as, for example, *Athyrium distentifolium* is for the regeneration of spruce, which is a light-demanding species in the upper montane spruce forest on Mt. Babia (*Babia Góra*) (Holeksa 1998). Głazek and Wolak (1991) researched the community with *Dryopteris dilatata* (=*D. austriaca*) with the share of the *Abies alba* forming the tall herbs in the subtopic parts of the quartzite stony slopes in the Holy Cross Mts., which occurred in mosaic with the *Abietetum albae* (=*A. polonicum typicum* in the variant with *Dryopteris austriaca*). *Oxalis acetosella*, *Athyrium filix-femina*, and *Rubus hirtus sensu stricto*, which were discussed above, were mentioned as being among the main components of the herb layer of that community. The density of fir trees in the forest stand at the level of 10—20%, the concave forms of the terrain, which is frequently wet and favours the accumulation of vegetable mould, make favourable conditions for the mass occurrence of *Dryopteris austriaca* and in some patches also *Athyrium filix-femina*, which are not shadowed by the fir from the canopy (Kobendza 1939; Głazek, Wolak 1991). However, this situation is opposite to the one that has been discussed in this book.

An interesting thing was that the lack of a moss layer did not make the growth of fir new-growths any easier (their mean height was only 5.9 cm), whereas close to a 10% share of mosses is connected with the achievement of the highest dimensions by the fir new-growths (on average 8.3 cm in height). It is possible that the small share of mosses raises the microretention of water in the soil and simultaneously does not restrict the access of seedlings to soil resources, which at this stage of development are forming the root. The presented studies prove that there is no definite relationship: the lower the moss cover, the higher fir new-growths. Rather, it should be acknowledged that the share of mosses in the lowest layer of the forest has no influence on the height of fir new-growths.

Hundreds and even thousands of years are included in the time scale of forest **dynamics**, because of the longevity of trees and the duration of a full cycle of life processes that take part in a forest. The spatial scale, in which particular processes are realised, is still being discussed. It is possible to observe many phenomena in the scale of a few or over a dozen ares, while others occur on an area of hundreds or even thousands of hectares (Wiens 1989; Botkin 1993; Szwagrzyk 1995; Holeksa 1998). Some phenomena of dynamics (competition) are studied on small areas and in short study series in practice; others (like the dispersion of diaspores, insects' gradation, the influence of global changes on vegetation, etc.), demand mathematical modelling (Szwagrzyk 1995).

The present studies cover a short period of observations and a small area, however, their results are comparable with studies done by other researchers who work on larger areas and conduct their observations over a longer period of time. The results of these studies give a positive answer to the question connected with the persistence of the phytocoenoses of the *Abietetum albae* association in the central part of the Cracow-Częstochowa Upland. This is confirmed by the structure and dynamics of the regeneration of that association (despite the small number of up-growths), as well as by the biological features of fir, which is distinctly shadow-tolerant, and therefore the future regeneration potential of the entire phytocoenose can be hidden in the herb layer of the forest as new-growths.

In a similar context, the question under consideration can reveal the state of maintenance and the development tendencies of the upland mixed coniferous fir forest on the entire range of its occurrence in Poland. When considering the data from recent literature (Święs 1985; Macicka, Wilczyńska 1990; Głazek, Wolak 1991; Izdebski et al. 1992; Fijałkowski 1993; Macicka-Pawlik, Wilczyńska 1995; Stachurska 1998; Marciniuk, Wierzba 2004; Rutkowski 2004; Matuszkiewicz J. M., Kowalska 2007; Orzechowski 2007), at least two opposite trends in the dynamics of the *Abietetum albae* can be noticed. On the one hand, some researchers write about the regression of the association from localities and habitats taken, losing its characteristic features and variability, multidirectional degeneration changes or the critical state of maintenance in some regions (their effect is, among others, a description of new syntaxa that have an incomplete structure and composition). On the other hand, other researchers write about their good and even very good condition or very strong regeneration processes. Both of these trends are visible in various localities of the association in the central part of the Cracow-Częstochowa Upland (see Chapter 5). The rule is that the best maintained or at least well maintained (also in the sense of dynamics) phytocoenoses of the upland mixed coniferous fir forests or communities, which are described as evident regeneration shapes — that is, after the previous transformation by a pine monoculture, are mainly in nature reserves, national parks and forests that include old mother forest stands and also in very extensively used forests that are owned by private agriculturalists. It must be stressed that *Abietetum albae* is practically and successively eliminated in places where there is intensive forest management, in particular, in the areas that are located at heights lower than 300 m a.s.l., where the so-called "upland site types" are not taken into consideration, and within their habitats from the group of habitats from mixed coniferous forests or mixed woods clear-cuttings are widely employed and then artificial regeneration, mainly by pine, is used, e.g., Trzebnicko-Ostrzeszowskie Hills region (see Brzeg, Rutkowski 2004). Observations made in the Jurassic area, as well as results presented by many other authors, show that the persistence and regeneration of the components of the type of ecosystem being discussed, which is valuable and protected by the habitat law of the Natura 2000, may be protected exclusively in the conditions of the permanent existence of multi-generation forest stands with a domination of fir. Only single trees may be eliminated (cut) from such a stand, and if necessary, small "fir regeneration nests" can be established in the gaps. Using larger areas of clear-cuts is forbidden.

Fir highlights the significant dynamics of natural regeneration in the lower layers of the forest under the conditions of sufficient shadow of forest interior under a forest stand with its share. There is no need to artificially plant it. This phenomenon is strongly visible even on the edges of the range of the *Abietetum albae* (see Dobrowolska 1998; Marciniuk, Wierzba 2004 — the Siedlecka Upland; Macicka-Pawlik, Wilczyńska 1995; Brzeg, Rutkowski 2004 — Ostrzeszowskie Hills). The significant dynamics of this tree in the phytocoenoses of the fir forest, as well as its strong regeneration tendencies in patches that were strongly transformed in the area of Kozienice Primaeval Forest were relatively recently described by Orzechowski (2007).

Contemporary visible transformations of the floristic composition in the upland mixed coniferous fir forests in relation to its historical documentations have been discussed recently. Matuszkiewicz J. M. and Kowalska (2007), as well as Matuszkiewicz J. M. (2007) paid attention to the following phenomena and problems:

1. The total richness of species in patches of the phytocoenoses is getting poorer from more than 40 taxa on average to approximately 25 taxa.
2. The diversity of the forest stands is getting richer, which is manifested by the appearance of such species as beech, birch, durmast, aspen, and rowan in pure fir forests, which is described as "politypisation," as opposed to "monotypisation" in the understanding of Olaczek (1974).
3. A decrease in the share of distinguishing species for the association and a rare characteristic for the *Vaccinio-Piceetea* class and also some accompanying species.
4. The loss of characteristic features of the *Abietetum albae* association and the possible need to describe a new syntaxon of the basal rank for the phytocoenotic arrangements that actually exist.

Regarding the above-mentioned issues based on the analysis of materials collected in the central part of the Cracow-Częstochowa Upland, the following should be understood:

1. The phytocoenoses of the upland mixed coniferous fir forest in the study area are rich in relation to the total floristic composition (the mean number of taxa in one relevé amounts to 38 in a typical subassociation and 48 in *A. a. circaeetosum alpinae*); this situation is rather comparable with historical documentations from other regions of the country than the above-mentioned contemporary trends.
2. The stands of the Jurassic fir forests that were studied are usually multispecies, mostly with a significant domination of fir, but with a frequent natural share of birch, beech, pine, and spruce, and rarely with an admixture of durmast or aspen. On the study area there was no patch in the case of

which the stand could be monotypised by the fir as the result of forest management. Instead, there was the only one patch (Table 3 rel. 18) in the case of which the stand was build exclusively by the fir in upper and lower sublayers and its quite high share in a herb layer provided the evidence of its natural, self-seeding origin. The local populations of fir are always of different ages and are differentiated according to the vertical and horizontal structure. The probable monotypisation of a single phytocoenoses (in the deeper or closer past) took place only in the case of the stands that were dominated by the spruce *Picea abies* in the upper sublayer. Supposedly, this type of patches or ones similar to them can be wrongly interpreted in the upland area of Poland as the edge shapes of subboreal *Querco-Piceetum* W. Mat. et Polakowska 1955.

3. In the case of the fir forests of the study area, it is difficult to discuss the poorness of the group of diagnostic species of the association because of the lack of comparable historical materials and a large enough share of this group of species. The fact that a small (with exception of the most common) share of species from coniferous forests that are characteristic for the *Piceion excelsae* alliance and *Vaccinio-Piceetea* class, in particular from the *Pyrolaceae* family seems to be in agreement with the opinion of Matuszkiewicz J. M. (2007). This all-country tendency can be interpreted both as the effect of the euthrophisation of the habitats or the withdrawal of pasturage from forests, but also (as it seems to be) of the climatic changes that are connected with global warming.
4. It is not possible to agree with the suggestion that the characteristic features and peculiarity of the *Abietetum albae* (=*A. polonicum*) are being lost in light of the studies on the upland mixed coniferous fir forest that was conducted in the central part of the Cracow-Częstochowa Upland, as well as based on the comparison studies of the entire range of the association in Poland (see Chapter 3.3, Table 5). Despite the changes in various regions that occurred in the aforementioned ecosystem, it is still easy to identify it in the field (even in cases of strong deformations differing it from the type that is caused mainly by forest management), thanks to the floristic combination and accidental features, such as the structure and dynamics of the stands or habitats taken into account. From practical, substantial, and also formal (ICPN rules) reasons, the authors of the present elaboration do not see any justification for any description other than the *Abietetum albae* Dziubałtowski 1928 syntaxonomic unit in the association rank for submontane-upland mixed coniferous forests that are fresh or moderately wet on mineral sites with a domination (significant share) of fir. Undoubtedly, further studies require that such questions as the status of the so-called boggy shapes (not present in the Jurassic area) that are given in the literature as "*Abietetum albae uliginosum*," the real range of the association in Poland and also its full local-habitat, regional and zonal (altitudinal) differentiation be answered.

7. Summary of results and conclusions

The aim of the present monograph was to describe the geobotanical characteristics of the *Abietetum albae* association Dziubałtowski 1928 (= *A. polonicum* (Dziub. 1928) Br.-Bl. et Vlieg 1939 *nom. illeg.*) that occurs in the area of the central part of the Cracow-Częstochowa Upland. Particular attention was paid to:
— the differentiation and the regional specificity of the association,
— its distribution and spread in this area,
— the conditions of its occurrence,
— the state of maintenance, dynamic tendencies, and structure,
— the existing and potential threats and forms of protection.

The studies were conducted in the years 2009—2011. In total, 52 phytosociological relevés were made using the Braun-Blanquet method. After the numerical analysis (Fig. 4 and 5), these relevés were included into two traditional analytic tables (Tables 3 and 4). The result was the differentiation of the *Abietetum albae* association in the region into two subassociations — typical (poorer) *A. a. typicum* J. Matuszkiewicz 1977 and richer (more fertile and wet) *A. a. circaeetosum alpinae* J. Matuszkiewicz 1977. The two new variants — typical and with *Milium effusum* were distinguished within the typical subassociation.

There is a comparison of the collected materials with those that came from various regions of Poland in a general table (Table 5). Therefore, in order to find the peculiarity of the association in the Jurassic area all country material was studied. This table compares a total of 733 phytosociological relevés of many authors in 34 columns. Based on its content a new Jurassic regional variety of *Abietetum albae* was distinguished. Its diagnostic features, as well as any similarities and differences in relation to the other varieties such as: the Silesian-Wielkopolska, the Subcarpathian, the Holy Cross, the Roztocze, and the Mazovian ones have been indicated. Lists of distinguishing taxa were made for the said varieties.

Patches of the upland mixed coniferous fir forest were hitherto identified and documented in the central part of the Cracow-Częstochowa Upland on 11 localities including two relevés that were made by Hereźniak (1993). Ten localities are new and are spread in the majority to the south of the Pilica river. Some of them are localities that are relatively large, namely, in the Wodąca Valley or in the Trzyciąż Forestry. In comparison with some of the other forest associations that have been recognized in this area to date, for example, the *Phyllitido--Aceretum* Moor 1952, the *Potentillo albae-Quercetum* Libbert 1933 *nom. invers.*, the *Calamagrostio-Quercetum petraeae* (Hartm. 1934) Scam. et Passarge 1959 *em.* Brzeg et al. 1989 and the *Calamagrostio villosae-Pinetum* Staszkiewicz 1958 *em.* Cabała 1989, the *Abietetum albae* should be acknowledged as quite recent in the region that was studied.

The research shows the patches of the association that were studied indicate a particular relationship with deficient weakly developed grey Luvisols that are moderately acid, made of sandy loams or clays from various depths, which have been deposited on deep-lying Jurassic limestones. These patches were mostly located in the lower parts of slopes or at the bases of hills, in local valleys, and very rarely on flat places. The phytocoenoses were documented in nature reserves, landscape parks and in areas of Natura 2000, as well as in managed forests and the private forests of agricultural owners.

The state of maintenance and the perspectives of the further persistence of the *Abietetum albae* in the area of the central part of the Cracow-Częstochowa Upland are quite differentiated and range from very good, through acceptable to bad, or even critical in some localities of a small area. Tendencies of the regeneration of the phytocoenoses after a previous degeneration can be observed in many places. The problem of the layered structure of fir forest patches and the dynamics of their regeneration with a fir share were studied in detail on permanent study plots I—VI, located in three main study localities — Goncerzyca in the Wodąca Valley, Hucisko Ryczowskie, and Trzyciąż. The forest stand, shrub layer, and herb layer, were analysed with particular attention being paid to new--growths. The most important results are presented below.

The forest stand. Fir is the most important and most numerous species that forms the stand on the study plots (I—VI) in the patches of the upland mixed coniferous fir forest *Abietetum albae* from the central part of the Cracow--Częstochowa Upland. The mean density of fir was described at a level of 375 individuals/ha, which is a high result on a supraregional scale. *Abies alba* reached a mean diameter of 35 cm, which ranges from a mean 26 cm on Goncerzyca to a mean 51 cm in Trzyciąż, depending on the locality. There is also a low and medium class of diameters. During the phytosociological studies in other localities of the association significantly higher values of diameters were also noted.

All admixture species of the forest stand (rowan, beech, pine, birch, and sycamore) that were found in the permanent study plots had diameters in an incomplete range (8—9 cm) or at least in a low class of diameters (10—39 cm) and are not competitive to the dominating fir. The exception from the state that was documented in the permanent study plots are the phytocoenoses that are present in other places where the upper sublayer of the stand is dominated by *Picea abies*, which is the effect of monotypisation. Moreover, in such patches the fir reveals good dynamics in lower layers of the forest in general.

Up-growths. Twenty-three young specimens (192 individuals/ha) of fir occurred in the up-growths on the area of 12 studied ares. The share of *Abies alba* up-growths in the medium and higher classes of the height of the discussed layer is a good prognostic indicator for the future, regarding the gradual reinforcement of fir in the higher layers of the forest. However, the general numbers of fir in the shrub layer (b) is too small to support natural regeneration in that layer.

New-growths. Eight hundred and twenty-nine individuals (34 individuals per 1 m^2 on average) of *Abies alba* creating new-growths occurred on the area of 24 m^2 (i.e. 24 squares on six study plots). This is the value that prevents the effective regeneration of fir in that layer. The shadow tolerance of fir and its abilities for long-term standing in a state of waiting for favourable conditions for growth and development may become a durable protection of its resources.

The highest diversity of the height of fir new-growths occurred on permanent plot II in Goncerzyca, and the lowest on permanent plot IV in Hucisko. Fir reached the highest mean value of the height of new-growths in Goncerzyca I and the lowest value in Hucisko III. The maximum differentiation of the values the heights of the fir new-growths ranged from 2 to 19 cm. In the majority of cases, there is lack of a statistically significant correlation between the height of the fir new-growth and the cover of particular species of vascular plants in the herb layer. Moreover, the cover of the moss layer has no specific influence on the height of fir new-growths.

The maximum values of fir cover in study plots I and II in Goncerzyca correspond to the cover of herb layer lower than 45%, while in Hucisko III, the minimum value of the cover of fir new-growth corresponds to maximum (higher than 60%) percentage cover of the herb layer. Between the cover of youngest firs and the cover of the moss layer it is not possible to settle any regularity in their relationships.

Athyrium filix-femina, *Oxalis acetosella*, and *Rubus hirtus et pedemontanus* are accompanying species for the fir regeneration stages in new-growths on all of the study plots. The last two species reveal a statistically important negative correlation with the cover of *Abies alba* in new-growths and are not favourable for its regeneration.

Schematic forest management is the most significant threat to the state of maintenance and persistence of the *Abietetum albae* association as it was determined, based on the conducted observations and the literature data. This fact not only reveals the area of studies, but the entire range of the *Abietetum albae* association. The peculiarity of upland's types of habitats in the schematic forest management, especially on the upland mixed coniferous site (BMwyż) and the upland mixed forest site (LMwyż) was not taken into the account. Moreover, large areas of clear-cuttings and then ploughing during the preparation of soil planting by monocultures mainly by pine and rarely spruce (or other species like e.g. birch, larch, or, locally, aspen) on habitats unified to mixed forest and treated as a lowland type of site were observed. Among the relatively less important dangers that appear only locally or for only a short period of time or to a lesser degree, are sheep pasturage, the isolation of small patches of fir forests among secondary forest communities, increasing touristic pressure, air pollution or weather anomalies, as well as the grazing of ungulates. Matuszkiewicz J. M. and Kowalska (2007) discussed the expansion of alien species (especially *Impatiens parviflora*) or invasive native species, such as *Calamagrostis villosa*, *C. epigejos*, *Rubus sp. div.*, or *Pteridium aquilinum*, which usually expand after the increase of amount of light reaching the floor in the fir forests. Their abundant growth can significantly change the character of phytocoenoses and the conditions of a habitat, which makes the proper regeneration of fir impossible, as well as it can change the reduction of share of the important and valuable components in the herb layer.

The upland mixed coniferous fir forest *Abietetum albae* represents a type of habitat that is mentioned in the Natura 2000 program, and therefore its phytocoenoses should be protected by law and their state of maintenance should be improved or at least sustained at the present level. In particular, it includes the areas taken by such forms of protection as national parks, nature reserves, landscape parks or the Natura 2000 areas, which undoubtedly need plans of protection. Based on the conducted studies and the observations, the following facts and suggestions should be taken into consideration during the creation and realisation of such plans:

1. The best maintained phytocoenoses of upland mixed coniferous fir forests, in which the only spontaneous processes of internal dynamics happen for a longer period of time and fir is present in all of the layers of the forest need only passive protection (the best solution is strict protection).
2. It is best to leave the phytocoenoses in the advanced stages of regeneration out of ingerention in order to make the natural processes of regeneration possible.
3. Patches that are somewhat strongly transformed need a directional but slow rebuilding of the forest stands. This process consists of gradual leaving out unwelcome species, e.g., larch, red oak, and pine that originated from monocultures and the restriction of the role of admixture species such as spruce, beech, birch, aspen or pine which originated from after-cutting seedlings, thus providing conditions for a stronger, natural regeneration of the fir or for partial planting of more fir specimens in each case within fenced areas.
4. Phytocoenoses that are very strongly transformed, as well as secondary forest communities on the potential habitats of the *Abietetum albae*, which should always reveal (despite the elevation a.s.l. of the given area) the upland types of

forest sites, require significant reconstruction. The speed, range and forms of this reconstruction should be dependent on local or regional conditions. The process itself should include a gradual reduction (up to the final elimination) of unwelcome species and prefer the fir (with a share of welcome admixture species) in artificial reconstruction groups under the canopy, which will have the character of a successively widening and/or multiplied "fir nests" that are fenced each time.

5. The so-called "management of a single tree" can be prescribed, in case of the need to use small and dispersed cuttings in a "nest shape" to create favourable conditions for the first of all natural regeneration of the fir in typical managed forests in the phytocoenoses of fir forests.
6. Multi-variant managed types of the forest stands that are dependent on local conditions, which can be included into the following scheme: *Abies alba* Jd (1)5—8, *Picea abies* Św 1—2(3), *Fagus sylvatica* Bk 0—1(2), *Betula pendula* Brzb 0—1(2), *Pinus sylvestris* So 0—1(2), *Quercus robur* Dbs 0—1, *Quercus petraea* Dbb 0—1, *Populus tremula* Os 0—1, where the abbreviations mean traditional Polish abbreviations of names of species used in forestry, and where the numbers in brackets are given for temporal regeneration stages, not for the final stands, can be recommended.

Appendix 1

List of endangered (EN), vulnerable (VU), nearly threatened (NT) and lowest care (LC) species found in patches of *Abietetum albae* in the central part of the Cracow--Częstochowa Upland (according to Parusel, Urbisz [eds.] 2012; Stebel et al. 2012)

Actaea spicata (LC),
Amblystegium serpens (LC),
Atrichum undulatum (LC),
Brachytheciastrum velutinum (LC),
Brachythecium rutabulum (LC),
Carex pilulifera (LC),
Chamaecytisus ruthenicus (EN),
Chimaphila umbellata (NT),
Circaea alpina (VU),
Climacium dendroides (LC),
Dentaria bulbifera (LC),
Dicranella heteromalla (LC),
Dicranum scoparium (LC),
Eurhynchium angustirete (LC),
Hepatica nobilis (NT),
Herzogiella seligeri (LC),
Hylocomium splendens (LC),
Hypnum cupressiforme (LC),
Kindbergia praelonga (LC),
Leucobryum glaucum (NT),
Lophocolea heterophylla (LC),
Lycopodium annotinum (LC),
Malaxis monophyllos (VU),
Mnium hornum (LC),
Moneses uniflora (NT),
Orthilia secunda (LC),
Orthodicranum montanum (LC),

Oxyrrhynchium hians (LC),
Plagiomnium affine (LC),
Plagiomnium undulatum (LC),
Plagiothecium curvifolium (LC),
Plagiothecium denticulatum (LC),
Plagiothecium laetum (LC),
Pleurozium schreberi (LC),
Pohlia nutans ssp. nutans (LC),
Polygonatum verticillatum (LC),
Polypodium vulgare (LC),
Polytrichiastrum formosum (LC),
Polytrichum commune (LC),
Pseudoscleropodium purum (LC),
Ptilium crista-castrensis (EN),
Rubus nessensis (NT),
Rubus pedemontanus (VU),
Sciuro-hypnum oedipodium (LC),
Thuidium tamariscinum (LC).

Appendix 2

List of geographical and proper names used in the monograph

Apennines (*Apeniny*),
Apolonka village (*wieś Apolonka*),
Aspromonte Mts. (*Góry Aspromonte*),
Austro-Hungaria (*Austro-Węgry*),
Bald Mountain (*Łysa Góra*),
Bald Mountain Forest (*Las Łysa Góra*) syn. Łysa Forest (Las Łysa),
Bardzkie Mts. (*Góry Bardzkie*),
Barycz river (*rzeka Barycz*),
Beech Mount reserve (*rezerwat Bukowa Góra*),
Belarus (*Białoruś*),
Beskid Mały Mts. (*Beskid Mały*),
Beskid Niski Mts. (*Beskid Niski*),
Beskid Sądecki Mts. (*Beskid Sądecki*),
Beskid Śląski Mts. (*Beskid Śląski*),
Beskids (*Beskidy*),
Biała Przemsza river (*rzeka Biała Przemsza*),
Biała, town section of Bielsko (*Biała, dzielnica Bielska*),
Białowieża Primaeval Forest (*Puszcza Białowieska*),
Biały Kamień Hill (*wzgórze Biały Kamień*),
Białystok,
Bielińskie Range (*Pasmo Bielińskie*),
Bielsko town (*obecnie miasto Bielsko-Biała*),
Bieszczady Mts. (*Bieszczady*),
Biśnik Rock (*Skała Biśnik*),
Black Forest (*Czarny Las*),
Bulgaria (*Bułgaria*),
Bystrzyckie Mts. (*Góry Bystrzyckie*),
Calabria (*Kalabria*),
Carpathian Foothills (*Pogórze Karpackie*),

Carpathian Primaeval Forest (*Puszcza Karpacka*),
Carpathian ranges (*karpackie pasma górskie*),
Carpathians (*Karpaty*),
Castle Mount (*Góra Zamkowa*) syn. Mt. Janowski (*Góra Janowskiego*),
Central Europe (*Europa Środkowa*),
Cieplice village (*wieś Cieplice*),
Cieszyńskie Foothills (*Pogórze Cieszyńskie*),
Cisowa Rock (*Cisowa Skała*),
Cracow (*Kraków*),
Cracow Jura (*Jura Krakowska*),
Cracow Upland (*Wyżyna Krakowska*),
Cracow-Częstochowa Jura (*Jura Krakowsko-Częstochowska*),
Cracow-Częstochowa Upland (*Wyżyna Krakowsko-Częstochowska*),
Cracow-Silesian Upland (*Wyżyna Śląsko-Krakowska*),
Cracow-Wieluń Upland (*Wyżyna Krakowsko-Wieluńska*),
Częstochowa,
Częstochowa-Kielce climatic district (*częstochowsko-kielecki okręg klimatyczny*),
Dark Cave (*Grota Ciemna*),
Dębczyna village (*wieś Dębczyna*),
Dłubnia Landscape Park (*Dłubniański Park Krajobrazowy*),
Dłużec village (*wieś Dłużec*),
Domiarki village (*wieś Domiarki*),
Dziadówki Forestry (*Leśnictwo Dziadówki*),
Dziadówki village (*wieś Dziadówki*),
Eagles' Nests Landscape Park (*Park Krajobrazowy Orlich Gniazd*),
Fir Primaeval Forest (*Puszcza Jodłowa*),
Foxy Mountain (*Lisia Góra*),
Galicia (*Galicja*),
Gdańsk,
Giebło Settlement (*Kolonia Giebło*),
Glanów village (*wieś Glanów*),
Goncerzyca Rock (*Skała Goncerzyca*),
Goncerzyca Rock, Strzegowa Poduchowne village (*Skała Goncerzyca, wieś Strzegowa Poduchowne*),
Gorce Mts. (*Gorce*),
Grey Oak Wood (*Las Siwa Dąbrówka*),
Grodzisko Chłopskie Hill (*wzgórze ostańcowe Grodzisko Chłopskie*),
Grodzisko Pańskie Hill (*wzgórze ostańcowe Grodzisko Pańskie*),
High Bieszczady Mts. (*Bieszczady Wysokie*),
Holy Cross Mts. (*Góry Świętokrzyskie*),
Holy Cross National Park (*Świętokrzyski Park Narodowy*),
Holy Cross region (*region Świętokrzyski*),
Holy Cross variety (*odmiana świętokrzyska*),
Hucisko Ryczowskie village (*wieś Hucisko Ryczowskie*),
Italian Alps (*Alpy Włoskie*),

Italy (*Włochy*),
Jangrot village (*wieś Jangrot*),
Janów town (*miasto Janów*),
Januszkowa Mountain (*Januszkowa Góra*),
Jaroszowiec village (*wieś Jaroszowiec*),
Jata Forestry (*Leśnictwo Jata*),
Jata reserve (*rezerwat Jata*),
Jeleniowskie Range (*Pasmo Jeleniowskie*),
Jurassic area (*Jura*),
Jurassic geographic varieties (*jurajskie odmiany geograficzne*),
Jurassic limestones (*wapienie jurajskie*),
Jurassic region (*region Jurajski*),
Jurrasic variety (*odmiana jurajska*),
Kaliszak reserve (*rezerwat Kaliszak*),
Kamień reserve (*rezerwat Kamień*),
Karlin village (*wieś Karlin*),
Katowice,
Kąpiele Wielkie village (*wieś Kąpiele Wielkie*),
Kielce,
Kiełkowice nad Dołami village (*wieś Kiełkowice nad Dołami*),
Kleszczowa village (*wieś Kleszczowa*),
Kleszczowski Forest (*Kleszczowski Las*),
Klonowskie Range (*Pasmo Klonowskie*),
Klucze town (*miasto Klucze*),
Kocikowa village (*wieś Kocikowa*),
Kolonia nad Dołami, Zawiercie quarter (*Kolonia nad Dołami, dzielnica Zawiercia*),
Kołomyja town (*miasto Kołomyja*),
Kosmołów village (*wieś Kosmołów*),
Kozienice Primaeval Forest (*Puszcza Kozienicka*),
Kraków,
Kroczyce town (*miasto Kroczyce*),
Kusięta village near Olsztyn (*wieś Kusięta koło Olsztyna*),
Kwaśniów Górny village (*wieś Kwaśniów Górny*),
Landscape Park of the Eagles' Nests (*Park Krajobrazowy Orlich Gniazd*),
Low Bieszczady Mts. (*Bieszczady Niskie*),
Lublin region (*Lubelszczyzna*),
Lublin,
Luminous Mountain (*Jasna Góra*),
Łódzkie Upland (*Powyże Łódzkie*),
Łódź,
Łysa Forest (*Las Łysa*) syn. Bald Mountain Forest (*Las Łysa Góra*),
Łysica Hill (*wzgórze Łysica*),
Łysogóry Range (*Pasmo Łysogór*),
Magura National Park (*Magurski Park Narodowy*),
Małopolska Upland (*Wyżyna Małopolska*),

Małopolska,
Mazovia (*Mazowsze*),
Mazovian variety (*odmiana mazowiecka*),
Michałowiec Forest (*Las Michałowiec*),
Michałowiec reserve (*rezerwat Michałowiec*),
Michałówka village (*wieś Michałówka*),
Miechów Upland (*Wyżyna Miechowska*),
Morusy village (*wieś Morusy*),
Mstów town (*miasto Mstów*),
Mt. Babia (*Babia Góra*),
Mt. Janowski (*Góra Janowskiego*) syn. Castle Mount (*Góra Zamkowa*),
Mt. Łysica (*Góra Łysica*),
Mt. Pilsko (*Pilsko*),
Mt. Rząsowy (Góra Rząsowy) syn. Rząsowy Rock (*Skała Rząsowy*),
Nida Basin (*Niecka Nidziańska*),
Ogrodzieniec town (*miasto Ogrodzieniec*),
Ojców National Park (*Ojcowski Park Narodowy*),
Ojców Valley (*Dolina Ojcowska*),
Oleśnicka Plateau (*Równina Oleśnicka*),
Olkusz town (*miasto Olkusz*),
Olsztyn near Częstochowa (*Olsztyn koło Częstochowy*) syn. Olsztyn town (miasto Olsztyn),
Olsztyn Refuge (*Ostoja Olsztyńska*),
Olsztyn town (miasto Olsztyn) syn. Olsztyn near Częstochowa (*Olsztyn koło Częstochowy*),
Opole Silesia (*Śląsk Opolski*),
Ostrzeszowskie Hills (*Wzgórza Ostrzeszowskie*),
Parkowe (*rezerwat Parkowe*),
Pazurek reserve (*rezerwat Pazurek*),
Pazurek village (*wieś Pazurek*),
Pieniny Mts. (*Pieniny*),
Pilica river (*rzeka Pilica*),
Pilica town (*miasto Pilica*),
Podduchowne Settlement (*osada Podduchowne*),
Podhale,
Podlesice village (*wieś Podlesice*),
Podlesie village (*wieś Podlesie*),
Pokucie,
Poland (*Polska*),
Polica Range (*Pasmo Policy*),
Polish Carpathians (*Karpaty Polskie*),
Polish Jura (*Jura Polska*),
Poręba Dzierżna village (*wieś Poręba Dzierżna*),
Poręba Forestry (*Leśnictwo Poręba*),
Poznań,
Prussia (*Prusy*),

Trzebnicko-Ostrzeszowskie Hills (*Wzgórza Trzebnicko-Ostrzeszowskie*),
Trzyciąż Forestry (*Leśnictwo Trzyciąż*),
Trzyciąż Inspectorate (*Nadleśnictwo Trzyciąż*),
Trzyciąż village (*wieś Trzyciąż*),
Udórz village (*wieś Udórz*),
Ukraine (*Ukraina*),
Upper Jurassic quest (*kuesta górnojurajska*),
Upper Silesian Industrial District (*Górnośląski Okręg Przemysłowy*),
Warszawa,
Warta river (*rzeka Warta*),
Western Bieszczady Mts. (*Bieszczady Zachodnie*),
Western Carpathians (*Karpaty Zachodnie*),
Western Galicia (*Galicja Zachodnia*),
White Stone Settlement (*Kolonia Biały Kamień*),
Wielickie Foothills (*Pogórze Wielickie*),
Wielkopolska,
Wieluń Upland (*Wyżyna Wieluńska*),
Wiercica River Valley (*Dolina Wiercicy*),
Wilkowska Valley (*Dolina Wilkowska*),
Wodąca River Valley (*Dolina Wodąca*),
Wodąca Valley (*Dolina Wodąca*),
Wola Kocikowa village (*wieś Wola Kocikowa*),
Wolbrom town (*miasto Wolbrom*),
Wrocław,
Zabagnie forest complex (*kompleks leśny Zabagnie*),
Zabagnie village (*wieś Zabagnie*),
Zagórowa village (*wieś Zagórowa*),
Zawiercie town (*miasto Zawiercie*),
Złoty Potok Inspectorate (*Nadleśnictwo Złoty Potok*),
Złoty Potok town (*miasto Złoty Potok*),
Złożeniec village (*wieś Złożeniec*),
Zubowa Rock (*Zubowa Skała*),
Żarki town (*miasto Żarki*),
Żelazko village (*wieś Żelazko*),
Żywiec region (*region Żywiecki*).

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Wyżynny jodłowy bór mieszany *Abietetum albae* Dziubałtowski 1928 w środkowej części Wyżyny Krakowsko-Częstochowskiej

Zróżnicowanie, specyfika regionalna, struktura, dynamika i stan zachowania

Streszczenie

Celem niniejszej monografii jest geobotaniczna charakterystyka zespołu *Abietetum albae* Dziubałtowski 1928 (= *A. polonicum* (Dziub. 1928) Br.-Bl. *et* Vlieg 1939 *nom. illeg.*), występującego na obszarze środkowej części Wyżyny Krakowsko-Częstochowskiej. Szczególną uwagę zwrócono na:
— zróżnicowanie i specyfikę regionalną zespołu,
— jego rozmieszczenie i rozpowszechnienie na tym terenie,
— warunki jego występowania,
— stan zachowania, tendencje dynamiczne i strukturę,
— istniejące i potencjalne zagrożenia oraz formy ochrony.

Badania prowadzono w latach 2009—2011. Uzyskano obraz zróżnicowania zespołu *Abietetum albae* w regionie na dwa podzespoły: typowy (uboższy) *A. a. typicum* J. Matuszkiewicz 1977 oraz bogatszy (żyźniejszy i wilgotniejszy) *A. a. circaeetosum alpinae* J. Matuszkiewicz 1977. W ramach podzespołu typowego wydzielono dwa nowe dla wiedzy warianty: typowy i z *Milium effusum*.

W celu ustalenia specyfiki badanego zespołu na Jurze porównano jego płaty z fitocenozami z różnych regionów Polski, co pozwoliło wyróżnić nową, jurajską odmianę regionalną *Abietetum albae*. Wskazano jej cechy diagnostyczne oraz podobieństwa i różnice w stosunku do innych odmian: śląsko-wielkopolskiej, podkarpackiej, świętokrzyskiej, roztoczańskiej i mazowieckiej, dla których sprecyzowano listy taksonów wyróżniających.

Na obszarze środkowej części Wyżyny Krakowsko-Częstochowskiej, uwzględniając dwa zdjęcia Hereźniaka (1993), płaty wyżynnej jedliny zidentyfikowano i udokumentowano dotychczas na 11 stanowiskach (w tym 10 nowych), rozmieszczonych w większości na południe od rzeki Pilicy. W porównaniu z niektórymi innymi zespołami leśnymi dotychczas rozpoznanymi na tym obszarze zespół ten należy uznać za dość rozpowszechniony w badanym regionie.

Stwierdzono, że badane płaty asocjacji wykazują szczególne powinowactwo do gleb płowych właściwych słabo wykształconych niecałkowitych, umiarkowanie kwaśnych, wytworzonych z glin piaszczystych lub iłów różnej miąższości, zdeponowanych na głęboko zalegających wapieniach jurajskich. Płaty te ulokowane były przeważnie w niższych partiach stoków lub u podnóży wzgórz, w lokalnych dolinach, rzadziej na miejscach płaskich. Dokumentowano je zarówno w rezerwatach przyrody, parkach krajobrazowych i obszarach Natura 2000, jak i w lasach gospodarczych zarówno państwowych, jak też prywatnych (chłopskich).

Stan zachowania i perspektywy dalszego trwania *Abietetum albae* na obszarze środkowej części Wyżyny Krakowsko-Częstochowskiej są dość zróżnicowane: od bardzo dobrego, poprzez zadawalający, po zły, czy nawet krytyczny na niektórych małopowierzchniowych stanowiskach. W wielu miejscach można zaobserwować tendencję do regeneracji fitocenoz po wcześniejszym zniekształceniu. Zagadnienie struktury warstwowej płatów jedliny i dynamiki odnawiania się

w nich jodły szczegółowo badano na 6 powierzchniach stałych (I—VI), zlokalizowanych na trzech stanowiskach badawczych (Goncerzyca w Dolinie Wodącej, Hucisko Ryczowskie i Trzyciąż). Analizowano tam zarówno drzewostan, jak i podszyt oraz runo ze szczególnym uwzględnieniem nalotów.

Drzewostan. Na powierzchniach badawczych (I—VI) jodła jest najważniejszym i najliczniejszym gatunkiem tworzącym warstwę drzewostanu. Średnie zagęszczenie jodły określono na poziomie 375 osobników/ha, co jest wynikiem wysokim w skali ponadregionalnej. *Abies alba* osiąga średnią pierśnicę 35 cm, która to średnia, w zależności od stanowiska badawczego, mieści się od 26 cm na Goncerzycy do 51 cm w Trzyciążu, czyli mieści się między niską a średnią klasą pierśnic, przy maksimum zamykającym przedział wartości wysokich na poziomie 99 cm.

Wszystkie stwierdzone na stałych powierzchniach domieszkowe gatunki drzewostanu (jarząb, buk, sosna, brzoza i jawor) mieszczą się w niepełnym przedziale pierśnic (8—9 cm) lub, co najwyżej, w niskiej klasie pierśnic (10—39 cm) i nie stanowią konkurencji dla dominującej jodły. Jodła na ogół wykazuje dobrą dynamikę w niższych warstwach lasu.

Podrosty. Na zbadanej powierzchni 12 arów wystąpiły 23 młode osobniki (192 osobniki/ha) jodły w podrostach. Udział podrostów *Abies alba* w średnich i wyższych klasach wysokości jest dobrym prognostykiem na przyszłość, jeśli chodzi o stopniowe zasilanie w jodłę warstwy podokapowej drzewostanu. Jednak ogólna ilościowość jodły w warstwie podszytu jest niewystarczająca dla podtrzymania naturalnego odnowienia.

Naloty. Na powierzchni 24 m^2, czyli 24 kwadratów na sześciu powierzchniach badawczych występuje 829 osobników (średnio 34 osobniki na 1 m^2) *Abies alba* tworzących naloty. Jest to wartość zapewniająca skuteczne jej odnowienie w tej warstwie, a dzięki cienioznośności jodły i jej zdolności do długotrwałego przebywania w stanie oczekiwania na sprzyjające warunki wzrostu i rozwoju może stanowić trwałe zabezpieczenie jej zasobów.

W większości przypadków brak istotnej statystycznie korelacji pomiędzy wysokością i pokryciem nalotu jodłowego a pokryciem poszczególnych gatunków roślin naczyniowych runa. Również pokrycie warstwy mszystej nie ma określonego wpływu na wysokość nalotu jodłowego. *Athyrium filix-femina*, *Oxalis acetosella* i *Rubus hirtus et pedemontanus* to gatunki, które na wszystkich powierzchniach badawczych towarzyszą odnowieniom jodły w nalotach. Dwa ostatnie z nich wykazują statystycznie istotną, ujemną korelację z pokryciem *Abies alba* w nalotach i ewidentnie nie sprzyjają jej odnowieniu.

Na podstawie przeprowadzonych obserwacji, jak i danych literaturowych można stwierdzić, że najpoważniejszym zagrożeniem dla stanu, jak i samego istnienia zespołu *Abietetum albae* nie tylko na obszarze badań, ale na jego całym obszarze zasięgowym, jest schematyczna gospodarka leśna, nieuwzględniająca specyfiki wyżynnych typów siedliskowych lasu, a polegająca na stosowaniu wielkopowierzchniowych zrębów zupełnych i po przygotowaniu gleby (orce) zakładaniu monokultur głównie sosnowych, rzadziej świerkowych (albo też innych, np. brzozowych, modrzewiowych czy lokalnie topolowych) na siedliskach klasyfikowanych do boru/lasu mieszanego, traktowanego jako typ nizinny. Do zdecydowanie mniej istotnych zagrożeń, pojawiających się tylko lokalnie, krótkotrwale bądź w małym natężeniach, zaliczyć można m.in.: wypas owiec, izolację małopowierzchniowych płatów jedliny wśród leśnych zbiorowisk zastępczych, zwiększający się ruch turystyczny, skażenie atmosfery czy anomalie pogodowe, a także żerowanie zwierzyny płowej. Zwraca się też uwagę (Matuszkiewicz J. M., Kowalska 2007) na rozprzestrzenienie się w jedlinach gatunków obcych (w szczególności *Impatiens parviflora*), bądź inwazyjnych gatunków rodzimych, np. *Calamagrostis villosa*, *C. epigejos*, *Rubus sp. div.* czy *Pteridium aquilinum,* następujące zwykle w efekcie prześwietlenia drzewostanu. Ich rozrost może znacząco zmieniać charakter fitocenoz i warunki siedliskowe, uniemożliwiając m.in. odnawianie się jodły i powodować redukcję udziału ważnych oraz cennych komponentów runa leśnego.

Wyżynny jodłowy bór mieszany *Abietetum albae* jest typem siedliska przyrodniczego w programie Natura 2000 i z tego tytułu jego fitocenozy powinny podlegać prawnej ochronie, a ich stan zachowania należy bądź poprawiać, bądź też przynajmniej utrzymywać. W szczególności dotyczy to terenów objętych takimi formami ochrony, jak: park narodowy, rezerwat przyrody, park krajobrazowy czy obszar Natura 2000, dla których konieczne jest okresowe opracowywanie planów ochrony. Na podstawie przeprowadzonych badań i obserwacji można stwierdzić następujące fakty i przesłanki, które powinny być brane pod uwagę podczas tworzenia i realizacji takich planów:

— najlepiej zachowane fitocenozy jedliny wyżynnej, w których od dłuższego czasu zachodzą jedynie spontaniczne procesy wewnętrznej dynamiki, a jodła jest obecna we wszystkich warstwach lasu, wymagają jedynie biernej ochrony zachowawczej (najlepiej ścisłej);

— fitocenozy znajdujące się w zaawansowanych stadiach regeneracji także najlepiej pozostawiać bez ingerencji, umożliwiając dalszą realizację zachodzących w nich naturalnych procesów;

— płaty silniej zniekształcone wymagają kierunkowej, ale powolnej przebudowy drzewostanów, polegającej na stopniowym usuwaniu gatunków niepożądanych (np. modrzewia, dębu czerwonego, sosny pochodzącej z monokultur) oraz ograniczaniu roli gatunków domieszkowych (świerka, buka, brzozy brodawkowatej, osiki czy też sosny wywodzącej się z pozrębowych samosiewów), tworząc warunki do silniejszego naturalnego odnawiania się jodły albo też jej częściowego dosadzania, w każdym przypadku na powierzchniach grodzonych;

— fitocenozy skrajnie silnie przekształcane oraz leśne zbiorowiska zastępcze na siedliskach *Abietetum albae*, które powinny odpowiadać zawsze (bez względu na wyniesienie danego terenu nad poziom morza) wyżynnym typom siedliskowym lasu, wymagają znaczącej przebudowy, której tempo, zakres i formy uzależnione powinny być od warunków lokalnych bądź regionalnych, a która powinna polegać na stopniowej redukcji (aż do ostatecznej eliminacji) gatunków niepożądanych, a preferowaniu jodły (z udziałem pożądanych gatunków domieszkowych) w sztucznych odnowieniach podokapowych o charakterze sukcesywnie poszerzanych i/lub pomnażanych gniazd, każdorazowo grodzonych;

— w typowych lasach gospodarczych w fitocenozach jedlin zalecić można tzw. gospodarkę pojedynczym drzewem, ewentualnie stosowanie drobnych i rozproszonych rębni gniazdowych, przy stwarzaniu warunków do przede wszystkim naturalnego odnawiania jodły;

— proponować można wielowariantowe, uzależnione od lokalnych warunków, gospodarcze typy drzewostanów mieszczące się w następującym schemacie: Jd (1)5—8, Św 1—2(3), Bk 0—1(2), Brzb 0—1(2), So 0—1(2), Dbs 0—1, Dbb 0—1, Os 0—1, gdzie cyfry w nawiasach podane są dla czasowych stadiów regeneracyjnych, a nie drzewostanów docelowych.

Алиция Барч, Анджей Бжег, Альдона К. Узембло, Станислав Вика

Высотный пихтовый смешанный бор *Abietetum albae* Дзюбалтовский 1928 в центральной части Краковско-Ченстоховской возвышенности Дифференциация, региональная специфика, структура, динамика и степень сохранности

Резюме

Цель настоящей монографии — геоботаническая характеристика ассоциации *Abietetum albae* Дзюбалтовский 1928 (= *A. polonicum* (Dziub. 1928) Br.-Bl. *et* Vlieg 1939 *nom. illeg.*), выступающей в центральной части Краковско-Ченстоховской возвышенности. Особенно подробно изучались:

— дифференциация и региональная специфика ассоциации,
— её размещение и распространение на данной территории,
— условия её существования,
— степень сохранности, динамика и структура,
— реальные и потенциальные угрозы, а также формы защиты.

Исследования велись в 2009—2011 гг. Была получена картина дифференциации ассоциации *Abietetum albae* в регионе на две субассоциации: типичной (более бедной) *A. a. typicum* Я. Матушкевич 1977 г., а также более богатой (более плодородной и влажной) *A. a. circaeetosum alpinae* Я. Матушкевич 1977 г. В рамках типичной субассоциации были выделены два новых для науки варианта: типичный и с *Milium effusum*.

Для того чтобы определить специфику исследуемой ассоциации на Краковско-Ченстоховской возвышенности, авторы сравнивали её участки с фитоценозами из различных регионов Польши, что позволило выделить новый, юрский, региональный сорт *Abietetum albae*. Были указаны его диагностические характеристики, а также сходства и различия по сравнению с другими сортами: силезско-великопольским, подкарпатским, свентокшиским, розточанским и мазовецким, для которых были уточнены списки отличительных таксонов.

На территории центральной части Краковско-Ченстоховской возвышенности, с учётом двух снимков Херезьняка (1993), участки возвышенной пихты до сих пор были идентифицированы и документированы в 11 пунктах (в том числе 10 новых), размещённых по большей части к югу от реки Пилица. По сравнению с некоторыми другими известными в настоящее время лесными ассоциациями, данную ассоциацию следует считать довольно распространенной в данном регионе.

Было установлено, что исследуемые пласты ассоциаций проявляют особенное родство с собственно бурыми слаборазвитыми умеренно кислыми почвами, образовавшимися из песчаных глин (суглинков) или илов различной толщи, расположенных на глубинных юрских известковых залежах. Данные пласты размещались по большей части в нижних частях склонов или у подножья возвышенностей, в локальных долинах, реже в плоских местностях. Они были задокументированы как в природных заповедниках, национальных парках и территориях «Натура 2000», так и в лесных хозяйствах — как государственных, так и частных.

Сохранность и перспективы дальнейшего существования *Abietetum albae* в центральной части Краковско-Ченстоховской возвышенности довольно сильно дифференцированы: от очень хорошей до удовлетворительной и плохой или даже критической на некоторых небольших отрезках. На многих территориях отмечается тенденция к регенерации фитоценозов после произошедших ранее деформаций. Вопрос послойной структуры пихтовых пластов и динамики регенерации подробно исследован на шести постоянных поверхностях (I—VI), локализованных на трёх исследовательских базах (Гонцежица в Долине Водонцей, Хучиско Рычовске и Тшичёнж). Был проанализирован как древостой, так и подлесок, а также растительный покров леса с особым учётом сеянцев и молодых пихт, достигающих не более чем 49.9 см.

Древостой. На исследуемых поверхностях (I—VI) пихта является важнейшей и самой распространённой породой, составляющей древостой. Среднюю плотность пихты авторы оценили на уровне 375 единиц/га, что можно считать высоким результатом по региональной шкале. *Abies alba* достигает среднего диаметра 35 см, который, в зависимости от расположения исследовательской базы, может колебаться от 26 см на Гонцежице до 51 см в Тшичёнже, т. е. находится между низким и средним классом диаметров при максимуме 99 см.

Диаметр всех обнаруженных на исследуемых поверхностях примесей других пород (рябина, бук, сосна, берёза и явор) колеблется в интервале 8—9 см или как максимум в низком классе диаметров 10—39 см, что не представляет конкуренции для доминирующей пихты. Пихта в целом демонстрирует положительную динамику в нижних ярусах леса.

Слой подростов. На исследуемой поверхности 12 соток зафиксировано 23 молодых экземпляра (192 экземпляра/га) пихты в подростах (0.5 м и выше, но не более чем 7.99 м). Доля подростов *Abies alba* в средней и высокой классах высоты позволяет делать положительные прогнозы на будущее, если речь идёт о постепенном распространении пихты в подкронном ярусе древостоя. Однако общее количество пихты в слое подлеска недостаточно для поддержания естественного возобновления.

Слой сеянцев и самых молодых пихт (не выше чем 49.9 см). На поверхности 24 $м^2$, т.е. 24 квадратов на шести исследуемых поверхностях, отмечается 829 экземпляров (в среднем 34 экземпляра на 1 $м^2$) *Abies alba*, создающих данный слой. Это количество обеспечивает эффективное возобновление, а благодаря тенеустойчивости пихты и способности пребывать продолжительное время в состоянии ожидания подходящих условий роста и развития может служить гарантией возобновления её запасов.

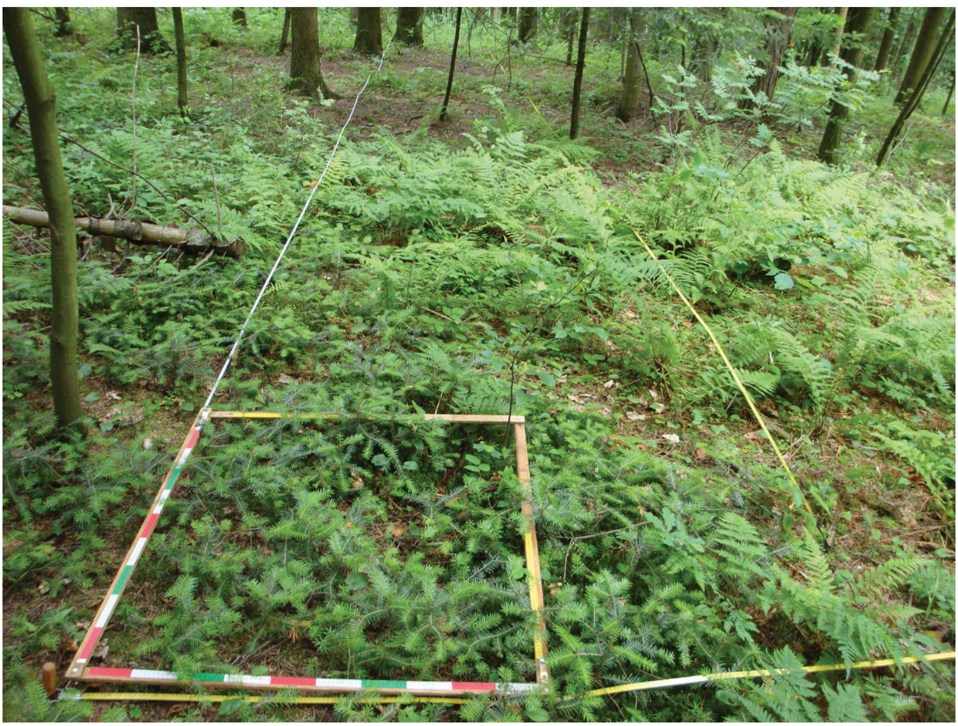
В большинстве случаев отмечается отсутствие статистически существенной корреляции между высотой и покрытием пихтовых сеянцев и самых молодых пихт (высотой не достигающих 0.5 м) и покрытием отдельных видов растений, составляющих растительный покров леса. Слой мха также не оказывает определённого влияния на высоту пихтовых сеянцев и самых молодых пихт. *Athyrium filix-femina*, *Oxalis acetosella* и *Rubus hirtus et pedemontanus* — это виды, которые на всех исследуемых поверхностях сопутствуют регенерации пихты в слое сеянцев и самых молодых пихт. Два последних демонстрируют статистически существенную отрицательную корреляцию с покрытием *Abies alba* в вышеназванном слое и, что очевидно, не способствуют регенерации пихты.

На основании проведённых наблюдений, а также данных специальной литературы, можно утверждать, что самой серьёзной опасностью для состояния, а также для самого существования ассоциации *Abietetum albae* не только на исследуемой части территории, но и на всей её протяжённости, является схематическое лесное хозяйствование, не учитывающее специфики высотных типов биотопа и применяющее масштабные вырубки с последующей подготовкой почвы (вспашке) к высаживанию монокультур, главным образом, сосновых, реже еловых (или также других, например берёзовых, лиственных либо, локально, тополевых) в биотопах, классифицируемых как бор/смешанный лес и относящихся к низинному типу биотопа. К гораздо менее существенным угрозам, появляющимся только локально, кратковременно или с небольшой силой воздействия, можно причислить: выгон овец, изоляцию небольших участков пихтовых фитоценозов среди замещающих лесных фитоценозов, увеличивающийся туристический поток, загрязнение атмосферы, аномалии погоды, а также обгладывание дерева животными. Обращается также внимание (Матушкевич Я.М., Ковальская 2007) на распространение в пихтовых насаждениях чужеродных видов (особенно *Impatiens parviflora*) или агрессивных отечественных видов, например *Calamagrostis villosa*, *C. epigejos*, *Rubus sp. div.* или *Pteridium aquilinum*, которые, как правило, появляются в результате прорежения древостоя. Их разрастание может значительно изменить характер фитоценозов и условия биотопов, препятствующее, в частности, регенерации пихты и приводящее к редукции участия важных и ценных компонентов растительного покрова леса.

Высотный пихтовый смешанный бор *Abietetum albae* — тип природного биотопа в программе «Натура 2000», поэтому его фитоценозы должны подлежать юридической защите, а степень их сохранности следует улучшать или по крайней мере поддерживать его актуальное состояние. Особенно это касается таких охранных территорий, как национальный парк, природный заповедник, территория «Натура 2000», для которых необходимо разработать временные планы защиты. На основании проведённых исследований и наблюдений можно выделить следующие факты и предпосылки, которые необходимо принимать во внимание во время разработки подобных планов:

— лучше всего сохранившиеся участки высотной пихты, в которых на протяжении многих лет происходят лишь спонтанные процессы внутренней динамики, а пихта присутствует во всех ярусах леса, нуждаются лишь в пассивной защите;
— фитоценозы, находящиеся на высокой степени регенерации, также лучше оставить без вмешательств, делая возможным дальнейшую реализацию происходящих в них естественных процессов;
— участки, сильнее затронутые изменениями, нуждаются в направленной, но постепенной перестройке древостоя, заключающейся в постепенной элиминации нежелательных пород (например лиственницы, красного дуба, монокультурной сосны), а также ограничении роли примеси других пород (ели, бука, берёзы повислой, осины и сосны, вырастающей как самосев после вырубки), что в конечном итоге создаст условия для более плодотворного естественного возобновления пихты. Возможно также дополнительное подсаживание, но исключительно на огороженных участках;
— крайне сильно деформированные фитоценозы, а также замещающие лесные фитоценозы в местах распространения *Abietetum albae*, которые всегда (в независимости от высоты данной территории над уровнем моря) должны соответствовать высотным типам биотопов, требуют значительной перестройки, темп, формы и объём которой должны зависеть от локальных или региональных условий. Перестройка должна основываться на постепенной редукции (вплоть до окончательной элиминации) нежелательных пород и предпочтении пихты (при участии желательных примесей других пород) в искусственно возобновлённых подкронных ярусах, имеющих характер последовательно расширяемых и/или умножаемых гнёзд, каждое из которых должно быть огорожено;
— в типичных хозяйственных лесах в фитоценозах пихты можно рекомендовать так наз. хозяйство единичным деревом или возможное использование небольших рассеянных гнездовых вырубок, прежде всего с целью создания естественного возобновления пихты;
— можно предлагать многовариантные, зависящие от локальных условий хозяйственные типы древостоев, находящихся в рамках следующей схемы: Jd (1)5—8, Św 1—2(3), Bk 0—1(2), Brzb 0—1(2), So 0—1(2), Dbs 0—1, Dbb 0—1, Os 0—1, где цифры в скобках даны для временных регенерационных стадий, а не конечных древостоев.

Phot. 1. "A" square with the new-growth of fir in the *Abietetum albae typicum* — Goncerzyca (11.06.2011, phot. S. Wika)



Phot. 2. New-growth study unit in the inner subarea of the study plot Goncerzyca (11.06.2011, phot. A. Barć)

Phot. 3. Age differentiation of the upland mixed fir coniferous forest in Hucisko (11.05.2010, phot. S. Wika)

Phot. 4. Interior of the upland mixed fir coniferous forest in Goncerzyca (11.06.2011, phot. S. Wika)

Phot. 5. Uneven-age fir new-growth in Goncerzyca (11.06.2011, phot. A. Barć)

Phot. 6. The *Abietetum albae circaeetosum alpinae* — Goncerzyca (rel. 3, 08.09.2009, phot. S. Wika)

Phot. 7. Abundant restoration of fir in the new-growth in Goncerzyca (11.06.2011, phot. S. Wika)

Phot. 8. Fir new-growth and the moss layer in Goncerzyca (11.06.2011, phot. S. Wika)

Phot. 9. Fragment of the herb layer in the *Abietetum albae typicum* — Goncerzyca (11.06.2011, phot. S. Wika)

Phot. 10. Heterogenous herb layer with uneven-aged fir new-growths in Goncerzyca (11.06.2011, phot. S. Wika)

Phot. 11. Tall and slim fir stand in Trzyciąż (26.05.2011, phot. A. Barć)

Phot. 12. Rowan up-growth in the upland mixed fir coniferous forest in Trzyciąż (26.05.2011, phot. A. Barć)

Phot. 13. Cleared and thinned forest stand of the upland coniferous mixed fir forest in Trzyciąż with broad-leaved species forming the shrub layer (26.05.2011, phot. A. Barć)

dr hab. Aldona K. Uziębło – adiunkt w Katedrze Geobotaniki i Ochrony Przyrody, a od 2014 roku w Katedrze Ekologii na Wydziale Biologii i Ochrony Środowiska Uniwersytetu Śląskiego w Katowicach. Autorka monografii „*Petasites kablikianus* Tausch ex Berchtold as a pioneer species and its abilities to colonise initial habitats" (2011) oraz ponad 40 artykułów naukowych. Jej zainteresowania naukowe skupiają się na: autekologii gatunku *Petasites kablikianus*, którym zajmuje się od ponad 20 lat, sukcesji roślinności na terenach popowodziowych, monitoringu ekosystemów leśnych znajdujących się pod wpływem antropopresji, ochronie przyrody w planowaniu przestrzennym oraz ochronie zieleni miejskiej. Jest członkinią Śląskiego Oddziału Polskiego Towarzystwa Botanicznego.

prof. zw. dr hab. Stanisław K. Wika – kierownik Katedry Geobotaniki i Ochrony Przyrody w latach 1994–2014, przepracował w Uniwersytecie Śląskim 42 lata, prowadząc badania w zakresie geobotaniki (fitosocjologii, fitogeografii, florystyki, kartografii), ochrony przyrody i ochrony środowiska na terenie Polski, Białorusi, Czech, Litwy, Rosji. Badał układy roślinne na poziomie fitocenozy i fitokompleksu krajobrazowego na siedliskach naturalnych, półnaturalnych i antropogenicznych. Jego dorobek obejmuje ponad 400 publikacji (w tym 30 książek, około 170 artykułów, ponad 170 prac popularnonaukowych, liczne komunikaty, mapy sozologiczne i notatki florystyczne), w tym wiele prac o florze i roślinności Syberii Wschodniej. Wypromował 21 doktorów oraz 137 magistrów.

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